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NR. 6. C. H. OSTENFELD: ON THE IMMIGRATION OF *BIDDULPHIA SINENSIS* GREV. AND ITS OCCURRENCE IN THE NORTH SEA DURING 1903—1907 AND ON ITS USE FOR THE STUDY OF THE DIRECTION AND RATE OF FLOW OF THE CURRENTS. (WITH 4 CHARTS AND 5 TEXT-FIGURES)

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
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BY

C. H. OSTENFELD

WITH 4 CHARTS AND 5 TEXT-FIGURES

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I. Introduction.

On examination of the plankton samples from the November 1903 seasonal cruise in Danish waters I found that a large and peculiar *Biddulphia* formed the main portion of the phytoplankton in the Skager Rak and northern part of the Kattegat. I saw immediately that this Diatom was *Biddulphia sinensis* Grev., well-known to me from plankton samples from the Red Sea and the Gulf of Siam, and which I had considered as an Indo-Pacific, neritic form belonging to tropical and subtropical coasts. Its appearance in the Skager Rak and that in great quantities seemed very strange and it seemed to me that it would be of hydrographical and biological interest to try and find out the facts regarding its appearance and distribution within the North Sea region. At the end of January 1904 I applied to the Central Bureau of the International Council for the Study of the Sea for permission to examine the plankton lists of the November cruises of the different nations, which the General Secretary, Dr. P. P. C. Hoek, willingly placed at my disposal. Of all the lists sent in only the Swedish Skager Rak contained *B. sinensis* and in them Prof. P. T. Cleve had given it as principal species, just as it was in the Danish lists. The other lists only contained *B. mobiliensis* (Bail.) Grun., a related species which also, though scarce, appeared in the Danish and Swedish Skager Rak samples. As these two species are somewhat alike, especially the form mentioned below, *B. regia*, which was included in the true *B. mobiliensis*, there was a possibility that *B. sinensis* had been among the specimens but had been considered *B. mobiliensis*. It would be quite excusable if such a mistake was made, as the investigators of the plankton would naturally pay more attention to the species belonging to the N. W. coasts of Europe and the northern Atlantic, and would not think of an Indo-Pacific, subtropical species such as *B. sinensis*. At the annual meeting of the International Council at Hamburg in February 1904 several plankton investigators spoke about the sudden appearance of *B. sinensis*, and on returning home I set about tracing its appearance and distribution within the region. Mainly by the aid of the Central Bureau plankton samples were sent me from England, Belgium, Holland and Germany, besides reports on the occurrence from Scotland, Sweden and Germany. Examination of the material and compilation of the information received enabled me to form a fairly complete picture of the appearance and occurrence of the species on the N. W. coasts of Europe in the autumn of 1903; I soon extended this also to include the February 1904 cruises. It was originally my intention only to publish the results of these two periods, but later — partly caused perhaps by delay in completing the work — I altered my plan, thinking it would be of great interest to follow the occurrence of the species in the North Sea region for some years, in order to see if it was able to maintain itself in this lately acquired territory, in other words to see if the immigration of *B. sinensis* into the North Sea was permanent or not.

After the lapse of five years I now consider it advisable to finish this investigation, particularly so as the methods under which the seasonal cruises are conducted are about to be altered and considerably changed.

In order not to be overpowered by the magnitude of the material I have chosen to limit the investigation of the occurrence of *B. sinensis* to the seasonal cruises: February, May, August and November and have only included other information, viz. lightship collections, for the winter 1903—1904.

The material for the investigation is nearly all taken from the plankton tables of the "Bulletin" (1904—1908), published by the Central Bureau of the International Council; some few data are found in papers published by the German "Kommission zur wissensch. Unters. der deutschen Meere" (APSTEIN, BROCKMANN, DRIVER and KRAEFFT; see the list of literature). Further, I have had information supplied and certain questions answered by Prof. C. APSTEIN, Mr. R. CLARK, the late Prof. P. T. CLEVE, Prof. G. GILSON, Dr. L. GOUGH, Prof. H. H. GRAN, Dr. P. P. C. HOEK, Cand. mag. J. P. JACOBSEN, Docent MARTIN KNUDSEN, Prof. OTTO PETTERSSON, Dr. H. C. REDEKE, Dr. P. J. VAN BREEMEN and Prof. H. VAN HEURCK, to whom I here take the opportunity of tendering my thanks for their help and courtesy.

The large plankton material published in the "Bulletin" has been, regarded as a whole, a splendid foundation for this investigation and it is to be hoped that more of this material will be further worked out as years go by; still, I may here call attention to several defects in it. In the first place, an examination four times a year is hardly sufficient to follow in detail the occurrence and periodicity of the organisms; also, it would — under present circumstances as far as four yearly periods are concerned — have been better to delay the cruises for a month, than to choose the months now used. Besides these general defects there are others, arising from the fact that the whole territory has not been regularly examined; the chief faults in this regard are that the northern part of the North Sea and the Norwegian Sea have only twice (May 1904 and May 1905) been investigated from the Norwegian side during the four years (Nov. 1903—May 1907) and that the western part of the North Sea, off England, has not been investigated at all; these two gaps have had the effect, e. g., that it has not been possible to follow with certainty the movements of *B. sinensis* southwards in the North Sea, and the explanation of this wandering has only been based on deductions; and most likely other investigations will over and over again suffer from these "missing links" in the chain of observations. All the other states, whose investigations affect the regions dealt with here, viz. the North Sea in its widest sense, except Sweden during the months of February and May 1906 (owing to the death of Prof. CLEVE), have regularly carried out the seasonal cruises and by this means procured this large and excellent material, without which an elucidation of the immigration and wanderings of a species — as the present paper hopes to be — would have been impossible.

The following remarks will deal with, firstly, briefly the distinction of *B. sinensis* from related species and its distribution outside the North Sea region, next, its immigration into the North Sea and appearance and wanderings there during the years 1903—07 and the connection of these wanderings with hydrographical data, and finally the importance of this for the study of the direction and rate of flow of the marine currents as well as for understanding the power of adaptation of the organisms.

The tables contain all the data for the occurrence of *Bidd. sinensis* arranged according to the seasonal cruises and to the different countries, and mostly taken from the "Bulletin".

The accompanying charts illustrate the occurrence of *B. sinensis* in the months: February, May, August and November of the years 1903—06, and have been constructed on the basis of all the observations specified in the tables.

II. Distinction from related species.

Biddulphia is a diatom genus rich in species. CHARLES S. BOYER (1900) gives for America about 70 species, nearly all of which also occur on the coasts of Europe. The species are generally fixed, marine coastal species. Most of them are characterized by a thick and very much sculptured siliceous wall and are thus not able to float as plankton. Apart from various species, which are accidently washed up by the waves and for this reason now and then appear in the plankton samples in small quantities and very irregularly, we may mention the following as more pronounced plankton forms, though they are all distinctly neritic: *B. aurita* (Lyngb.) Bréb., *B. granulata* Roper, *B. regia* (M. Schultze), *B. mobiliensis* (Bail.) Grun. and *B. sinensis* Grev., to which may be added the species described during the last few years: *B. hyalina* Schröder from San Francisco Bay, *B. striata* Karsten and *B. contorta* Karsten from the Antarctic Ocean and *B. agulhas* Karsten from the southern subtropical Atlantic.

The species are distinguished one from another by differences in the sculpture of the valves, their shape and the supply of processes and spines. If we examine the contents of a plankton sample under the microscope we find the Biddulphia species in most cases lying in such a position that we can see the cell in the broad side-view. In this view the two valves are seen connected with each other by a girdle of rectangular outline and each provided with two, more or less prominent processes, one at each corner. The shape of the outline between these processes, namely the surface of the valve, is of special importance as a distinguishing mark; this surface is often provided with two spines, the position of which is also of importance. The above-mentioned plankton species and their distinguishing characters are put down in the accompanying key; the cells are always supposed to be seen in side-view. For the species occurring more occasionally in the plankton see H. H. GRAN's paper in "Nordisches Plankton" (1905).

Key to the plankton species of Biddulphia.

I. Cells twisted; processes small, short; no spines ..... *B. contorta* Karsten.

II. Cells not twisted; spines present.

1. Valve with three rounded elevations inside the processes; spines two on the central elevation ..... *B. agulhas* Karsten.
2. Valve with one central elevation bearing (usually) two spines; girdle sharply limited against the valves.
   a. Sculpture coarse, processes diverging ..... *B. aurita* (Lyngb.) Bréb.
   b. Sculpture fine, processes parallel ..... *B. hyalina* Schröder.
3. Central part of the valve flat or depressed (concave); spines projecting near the processes.
   a. Processes small, short; spines four; sculpture fine; depression very faint ..... *B. striata* Karsten.
   b. Processes well developed; spines two.
      α. Valve well limited against the girdle, with numerous small granules or setæ; sculpture rather coarse ..... *B. granulata* Roper.
      β. Valve going evenly over into girdle; no granules; sculpture fine.
         * Valve with a large rather deep depression; spines projecting from small elevations close to the short, nearly parallel or faintly incurved processes ..... *B. sinensis* Grev.
         ** Valve with two small depressions inside the processes and a central, somewhat elevated, nearly flat part.

† Central elevated part much larger than the depressions, flat or faintly concave; spines much nearer the processes than the centrum; processes rather small, somewhat diverging; distal part of spines oftenest converging ..... *B. regia* (Schultze).

†† Central elevated part not much larger than the depressions, flat; spines half way between the processes and the centrum or nearer to the centrum; processes long, distinctly diverging; spines straight, diverging.. *B. mobiliensis* (Bail.) Grun.

It is evident from this key that the three species *B. sinensis*, *B. regia* and *B. mobiliensis* are most nearly related, and it is only among these that mistakes are likely to be made in their identification. For that reason I have given some drawings in order to show the differences between them. The figures are drawn with the same enlargement and I have given 1° a fully developed cell of each species, 2° two daughter cells produced by recent division; it will be seen how the proportion between length and breadth varies considerably according to the development (age) of the cell. The two forms *B. mobiliensis* and *B. regia* are generally regarded as one species, but I think wrongly. *B. sinensis* is a little more different from the other two, but as one never expected to find this Indo-Pacific species on the N. W. coasts of Europe, it was possible that this too had been placed under *B. mobiliensis*. On account of this I examined several plankton samples from the English Channel and the southern part of the North Sea collected in 1903, but did not find it; on the other hand *B. mobiliensis* and allied forms were present in quantity and my examination of the samples resulted in that I decided to keep *B. regia* and *B. mobiliensis* separate from each other, although nearly related. M. Schultze (1889) who founded the species *B. regia* under the name of *Denticella regia*, also pointed out its close relationship to *D. mobiliensis* Bailey. I have never found transitions between them and feel sure that they are quite separate species, distinguished — as the drawings show — by the characters mentioned in the key. Further, they are distinguished by the larger or smaller number of the chromatophores and by their shape, besides by the size of the cells. A series of measurements of the length and breadth of the cells of all three species — ten specimens of each — is given here; it will be seen that *B. sinensis* is the largest, next *B. regia* and last *B. mobiliensis*.

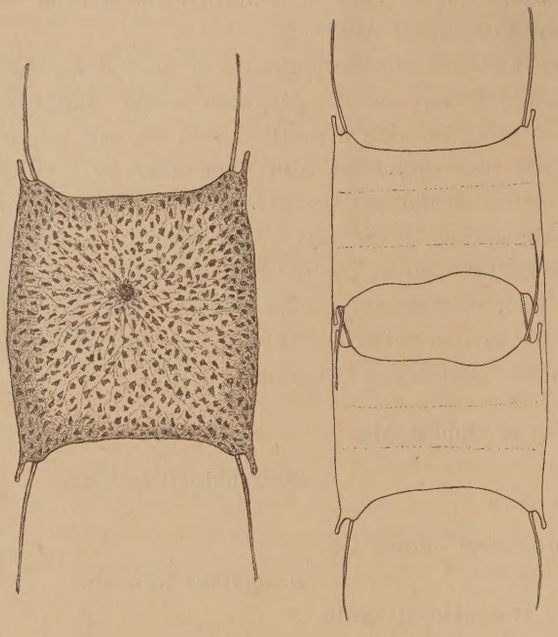

Fig. 1. *Biddulphia sinensis* Grev.
A fully developed specimen with chromatophores and nucleus; two newly formed daughter-cells (Zeiss' comp. ocular 8, apochrom. objective $\frac{8,0}{0,65}$, magnification about $\frac{165}{1}$).

B. regia is a more southern form belonging to the southern part of the North Sea and the English Channel. I have never found it in the Skager Rak or Kattegat, where on the other hand *B. mobiliensis* is a commonly occurring

Table showing the length and breadth of

B. sinensis	*B. regia*	*B. mobiliensis*
256 × 328	192 × 220	90 × 90
228 × 412	216 × 232	88 × 94
220 × 300	200 × 308	100 × 104
224 × 312	208 × 260	82 × 78
236 × 268	304 × 260	94 × 94
276 × 260	184 × 232	82 × 86
232 × 428	228 × 264	78 × 66
228 × 324	208 × 268	70 × 102
248 × 324	192 × 240	78 × 82
256 × 248	212 × 240	106 × 84
Average: 240 × 320	214 × 252	87 × 88

species. How far its distribution extends otherwise, I do not know, because as before mentioned it has always been mixed up with *B. mobiliensis*. The latter is a widely distributed temperate and subtropical coastal species, found on both coasts of the Atlantic, and recorded from the Indian Ocean and the Pacific.

CHR. BROCKMANN (1906) seems to have noticed that *B. mobiliensis*, as the species is generally regarded, is a collective name, for he writes: "Unter dem Namen *B. mobiliensis* sind eine Reihe verschiedener Formen vereinigt", and says that in the Weser and at Cuxhaven he has mainly found one form which he figures and which is *B. regia*. He also draws the true *B. mobiliensis* taken in a sample from the Bay of Bengal. GRAN (1905), who also figures both species, appends to the figure representing the true *B. mobiliensis* "Christianiafjord" and to the one representing *B. regia* "Ostende", which agrees with the above-mentioned information concerning the geographical distribution of the species. BROCKMANN's statement (l. c., p. 11) that "Es dürfte nicht schwer halten, aus den heterogenen Formen von *B. mobiliensis* und *B. sinensis* eine Zusammenstellung zu machen, die einen ununterbrochenen Uebergang von der einen zur andern Art abgäbe", I cannot agree with. It is probably just the confusion of *B. mobiliensis* with *B. regia*, the latter of which comes closer in its characteristic to *B. sinensis*, which has given rise to this statement. On the other hand I can fully endorse his remarks following immediately after: "und doch glaube ich, dass nicht nur beide guten Arten sind, sondern dass die jetztige Abgrenzung beider noch mehrere wirkliche Arten einschliesst" — namely *B. regia* and perhaps other forms.

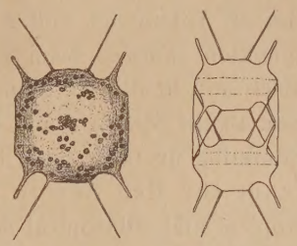

Fig. 2. *Biddulphia mobiliensis* (Bail.) Grun. A fully developed specimen with chromatophores and nucleus; two newly formed daughter-cells. (Same magnification as in Bidd. sinensis.)

The many figures published of *B. mobiliensis* sens. lat. should then be divided between the two species as follows:

B. mobiliensis (Bail.) Grun.; Bailey, Smithson. Contrib. Knowledge, II, 1851, Pl. 2, figs. 34—35 (*Zygoceros* [*Denticella*?] *mobiliensis*); Roper, Transact. Microsc. Soc. London, N. S., VII, 1859, Pl. 1, figs. 5—9 (*B. Baileyi*); Smith, Synopsis Brit. Diat., II, 1852, Pl. 45, fig. 322 c, Pl. 62, fig. 322 b (non d) (*B. Baileyi*); Ostenfeld, Botan. Tidsk., vol. 25, 1902, fig. 22; Gran., Nord. Plankton, 1905, Fig. 138 d (non e); Pavillard, Flore pelag. de l'étang de Thau, 1905, Pl. 3, fig. 11; Bergon, Bull. Soc. Bot. de France, 54, 1907, Pl. V—VIII (rapproaching *B. regia*); H. Peragallo, Soc. sc. d'Arcachon, Stat. Biol., 10. année, 1907, Pl. 1—2; Brockmann, Wiss. Meeresuntersuch., 1906, Fig. 6 d.

B. regia (M. Schultze); M. Schultze, Quartl. Journ. Microsc. Sc., London, VII, 1859, p. 21, Pl. 2, figs. 11—12 (*Denticella regia*); V. Heurck, Synopsis Diatom. Belg., Pl. 103, fig. A (*B. mobiliensis*); Smith, Synopsis Brit. Diatom. II, 1852, Pl. 62, fig. 322 d (*B. Baileyi*); Gran, Nord. Plankton, 1905, Fig. 138 c (*B. mobiliensis*); Brockmann, l. c., 1906, Fig. 6 a—c (*B. mobiliensis*).

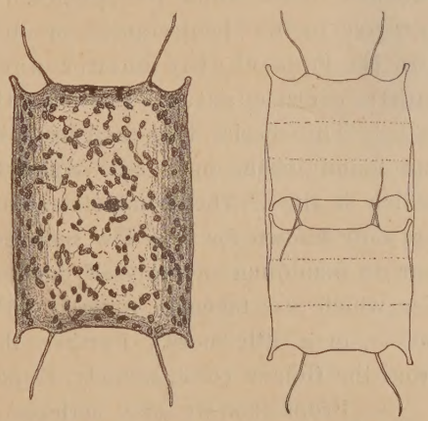

Fig. 3. *Biddulphia regia* (M. Schultze). A fully developed specimen with chromatophores and nucleus; two newly formed daughter-cells. (Same magnification as in Bidd. sinensis.)

To these may be added the hitherto published figures of

B. sinensis Greville; Transact. Microsc. Soc., London, 1866, Pl. 9, fig. 16; A. Schmidt, Atlas der Diatom.-kunde, Pl. 122, figs. 22—24; Ostenfeld & Schmidt, Vidensk. Medd. Naturh. Forening, København, 1901, Fig. 6; Ostenfeld, Botan. Tidsskr., 1902, fig. 21; Gran, Nord. Plankton, 1905, fig. 139; Van Breemen, Verhandl. Rijksinst. Onderzoek d. Zee, 1906, 1 Deel, V, Pl. 1, figs. 1 a—b; Brockmann, l. c., 1906, Fig. 7; Brockmann, Aus der Heimat — für die Heimat, N. F., Heft 1, 1908, Fig. 3 a, b.

III. Occurrence outside the North Sea and the Baltic.

K. Greville in 1866 in a paper on various new and rare diatoms described *B. sinensis* (or as he wrote it "*chinensis*") as found in a sample of diatoms from Hongkong. The next information is from P. T. Cleve (1873) who found it in a sample from the Sea of Java (Lat. S. 4° 20′, Long. E. 105° 22′). E. O'Meara reported it in 1879 as collected by the Challenger Expedition on the surface in the Yeddo Sea off Yokohama, aud A. Schmidt figures it in 1888 from specimens from Bengal. I found it myself in plankton samples from the Red Sea and the Gulf of Aden as well as from the Gulf of Siam (1901 and 1902) and finally, B. Schröder (1906) records it from the Red Sea, Arabian Sea, Singapore, N. W. Sunda Sea, Banka Straits, South China Sea, Formosa Channel, East China Sea of Japan (Enochima and Akashi). Summing up these data, the result is that *B. sinensis* is a neritic plankton form which extends from the Red Sea to Japan, that is, along the tropical coasts of the Indian Ocean and along the tropical and subtropical coasts of East Asia; in other words, *B. sinensis* is an Indo-Pacific coastal form and has a wide but well-defined distribution. As far as I know, it has not been found along the whole of the Pacific coasts of America, nor at the Sandwich Islands, New Zealand or the east coast of Africa, but the information on the plankton from these parts of the globe is very slight.

When we now leave the Indo-Pacific territory and proceed to the Atlantic, we can — apart from the territory we are going to discuss later — only find one statement, by P. T. Cleve (1900), namely, that it occurred in small numbers in two plankton samples taken off the coasts of Guiana:

March 1898: 7° N. Lat.; 55° W. Long.
June 1898: 10° N. Lat.; 53° W. Long.

On the other hand it is not known from the W. coast of Africa, the Mediterranean and S. and W. coast of Europe, nor from the E. coast of North America. Still it may be mentioned that knowledge of the plankton occurring along the whole E. coast of America is extremely slight, so that we cannot conclude much from its absence. On the other hand it would certainly have been recognised if it occurred in the Mediterranean or on the W. coast of France. *B. sinensis* seems therefore — except for its remarkable occurrence on the Guiana coast — to be lacking on the tropical and subtropical coasts of the Atlantic.

The species is — as constantly mentioned — a pronounced coastal, neritic form, which is not found in the open sea. Apart from this we do not know much about the outer conditions under which it lives. The usual statements regarding the water, namely, its temperature and salinity, are only known for very few samples. We find naturally no information about these in the older data, nor do Schröder or I myself mention the temperature or salinity; except for the sample from the Red Sea which was taken in water of 26°7 C.; the salinity is not stated but may certainly be given as about 36 ‰, or a little more. Further, the temperature and salinity are given by Cleve for the two samples from the Guiana coast, namely, respectively 26°9 C. and 36·01 ‰, and 27°2 C. and 36·01 ‰.

From this we may perhaps conclude that the species belongs to water with a temperature of 26°—27° C. and a salinity of 36 ‰. Still there is no doubt that the temperature of the Sea of Japan, where it occurs, is considerably less, while at the same time the salinity is certainly not higher than 34—35 ‰. In the following we will find that it occurs in the North Sea and adjacent seas in water of very different temperature and salinity.

IV. Immigration into the North Sea in 1903.

Chart I.

According to all the plankton-lists published in the "Bulletin" *Biddulphia sinensis* was nowhere found in the North Sea in August 1903, but in November 1903 the conditions were quite different. In the "Bulletin" we find it entered on the lists sent from Germany (Eastern North Sea), Sweden (Skager Rak) and Denmark (Skager Rak and Kattegat) and in most samples it is listed as the principal form. Chart I shows the stations where it occurred as well as the stations at which it was not found, according to my own investigations and to information from plankton investigators. The same method is used on the other charts which give its occurrence for the following years. All the data are mainly taken from the Bulletin's plankton tables, but a few observations are from other sources: from certain papers, from written communications by different plankton investigators, and from my own investigations.

All the planktion stations which gave *B. sinensis* are entered on the charts, and as most of the plankton tables also give the relative frequency of the species, different marks are used corresponding to the different frequencies. Unfortunately the German plankton tables ceased to give the relative frequency in 1905, and it has been necessary to introduce a new mark to indicate merely the occurrence. Again, most stations where *B. sinensis* was not found within a territory ranging from 63° N. Lat. to 50° N. Lat. and from 2° W. Long. to 20° E. Long., are also given on the charts. The marks for the absence and different frequencies of occurrence are explained on Chart I, to which the reader may refer.

In November 1903 the distribution of *B. sinensis* covered a territory which extended westwards to not quite 4° E. Long., southwards to the mouth of the river Elbe and eastwards to the Skager Rak and Kattegat to ca. 56° 30′ N. Lat.

The following question will naturally arise: How can we explain this sudden and numerous appearance of a plankton diatom in regions of the North Sea, unknown there up to now? When we consider its size, it is not likely that it could have been overlooked before, more probable it may be that a mistake respecting its identity with the nearly related *B. mobiliensis* and *B. regia* has been made. If such were the case one could explain its immigration easily, as *B. mobiliensis* and *B. regia* occur in the southern part of the North Sea and in the English Channel and *B. mobiliensis* in the N.W. part of the North Sea (at Scotland). For this reason I procured plankton samples from the Channel and the Belgian and Dutch regions of the North Sea for August as well as for November, but in none of them could I find the slightest trace of *B. sinensis*. Further, Mr. Robert Clark examined the Scottish plankton samples at my request after I had sent him a sample of *B. sinensis* for comparison, but it was not possible to find it there either. According to this it seems that *B. sinensis* is not carried by the currents into the North Sea from the north or from the south, and that it has not come from the east, viz. the Baltic, appears from the following, in addition to the fact that it would be absurd to assume such an origin. There is a slight possibility that a single individual, or a few stray specimens followed the current, for instance, through the English Channel, and on reaching the mouth of the Elbe found the conditions so favourable that they increased rapidly, which resulted in the sudden appearance in quantities of the species. Apart from the absence of the species in the samples from the Channel and southern part of the North Sea, all knowledge we possess concerning its distribution is against this possibility; as above described (p. 8) it is only known in the Atlantic region from two samples found off the coast of Guiana, and if it exists at all along the Atlantic coasts of Europe, it is very remarkable that it should have escaped notice. Professor P. T. Cleve who knew the species well from the Indo-Pacific seas has examined so many plankton samples from widely different regions of the Atlantic that we can safely assert its occurrence there as very sporadic, if it occurs at all at other places than those mentioned. (It was not found in a few plankton samples from the waters of the Danish West Indies (Caribbean Sea) which I examined.)

Further, it would be absurd to suppose that a species like *B. sinensis* whose home in the Indo-Pacific regions is along subtropical and warm temperate coasts, could not find suitable conditions in the most southern part of the North Sea and in the Channel, where the temperature of the water would seem more likely to agree with it than that further north, but waited to reproduce to any degree worth mentioning till it reached the mouth of the Elbe. Its later appearance in great quantities in 1904 and 1905 (see p. 15 and p. 17) on the coasts of Belgium and Holland shows too that when once it reaches there it can grow — and under very favourable circumstances. I can only say therefore that we may reject the supposition that a few (perhaps one) individuals were carried into the North Sea through the Channel. Taking into consideration the comparatively cold water of the north of Scotland the possibility of an immigration from there is so slight that the negative result of CLARK's investigation was the only one that could be expected; this possibility may therefore also be excluded.

CLEVE's many years' and extensive investigations of the plankton in the North Sea exclude one more possibility, namely, that the species was stationary in the plankton of the North Sea earlier than 1903.[1]

As far as I can judge there is no other explanation of *B. sinensis'* sudden appearance in the North Sea than the following: it has been drawn in from afar by the aid of man, that is to say, carried along from distant oceans by some ship, for instance attached to the outside or growing in the water of the hold. Many things favour the possibility of this hypothesis besides the exclusion of the other possibilities, namely, if we inquire where it first occurred in the North Sea, we find that it was in the S. E. corner, consequently off Hamburg where the enormous shipping makes the possibility that a ship brought it the greatest probability. The information concerning the occurrence of our diatom first at this place does not spring from the November seasonal lists; these only give the distribution of the species at this period; but this information may be traced to plankton investigations made from Danish lightships every fortnight. At the lightship "Horns Rev" (55° 34′ N. Lat., 7° 19·5′ E. Long.) the plankton sample from October 1st 1903 contained no *Bidd. sinensis*, while this species was the main form on October 15th as well as in November—February; at the lightship "Skagens Rev" (57° 46′ N. Lat., 10° 43·3′ E. Long.) *Bidd. sinensis* was not found in the samples from 1st nor in that from October 15th, but it was the main form on the 2nd of November.[2] The species has therefore as a natural consequence followed the north-going current (the Jutland current) which is specially pronounced during the autumn months. Comparing this with its rich occurrence off the mouth of the river Elbe and at Heligoland in the November cruise and its absence in the waters off the Zuidersee, we may conclude that its home is the S.E. corner of the North Sea where the river Elbe opens and whither the enormous mercantile Hamburg fleet directs its course. The individuals carried along have here found conditions most suitable for their growth: a water containing splendid nutritive conditions brought down by the river, a suitable salinity (33—34 ‰) and a favourable temperature (12°—14°); still we may note, as will be discussed later on, that the species seems to be rather euryhaline and eurythermic, and it seems as if the great nutritive qualities contained in the coastal waters had been the deciding factor.

Such a supposition, that the species has been carried from far distant places by ships, is not at all without parallels in the case of the larger, fixed algæ. We often find remarks about this in the literature on the algæ, and recently F. BØRGESEN (1905, pp. 819—820) has brought together the different observations concerning it. I may mention a few of the most convincing examples, from which it will be evident that a species not belonging to the flora of the place in question can thrive in or close to harbours. According to BORNET the brown Alga *Chorda filum* is found in the harbour of Nizza and no-

[1] Professor APSTEIN tells me that he had examined plankton samples from the North Sea from 1894 and 1902 without finding it, and it was not in any of the earlier samples from the North Sea I myself have examined.

[2] Concerning the more detailed dates for the occurrence of the species at the lightships, see later (p. 23).

where else in the Mediterranean. It must have been brought from the Atlantic coast, and the transplanting has in this case taken place from north to south; *vice versa* the red Alga *Hypnea musciformis* is found in the English Channel, otherwise it is only found further south. The most striking example is the red Alga, *Bonnemaisonia hamifera*, whose home is the coast of Japan and California, but which was found some years ago on the coast of England and later, on the coast of France (Cherbourg).

This is clearly parallel to the appearance of *Bidd. sinensis* in the North Sea: an Indo-Pacific species imported to the territory of the Atlantic. Whether this Bonnemaisonia will continue for a longer period in the Channel and perhaps spread, we cannot tell; according to statements by A. D. Cotton (1908, p. 77) it is still up to the present date to be found, but is not very common, but "is confined to certain spots", and "is found in very small quantity only." This is however, as we shall see in the next part of this paper, the case with *Bidd. sinensis*; it has become quite established in the North Sea along the continental coast from the mouth of the English Channel and northwards into the Skager Rak.

During late years a similar example of such a sudden immigration has been proved to have taken place in a very short time and is worth mentioning here, namely the brown Alga *Colpomenia sinuosa* whose homestead is in the Mediterranean and which is also recorded from the S. W. Atlantic coast of Spain, but had not been heard of further north till lately. During the last few years it has wandered northwards along the coast of France and has also reached the south coast of England. The first time we heard of its appearance was in a communication of 1906 from M. Fabre-Domergue, Inspector-General of Marine Fisheries, who stated that it was seen at Vannes in the Gulf of Morbihan where it caused much anxiety amongst oyster cultivators. It appeared in large quantities and the damage it did the oyster beds consisted of the following: the alga has a globular body (the older plant very often irregularly lobed), about the size of a tennis ball, attached by a narrow base to other algæ, to firm rock, or to loose objects at the bottom such as stones or oysters. Its interior is generally filled with water, but if it gets exposed at low-tide air enters it from below, and when high-tide again reaches it the air is shut in like a balloon. The specimens which have fastened themselves on oysters are by means of the enclosed air able to float (if the oyster is not too heavy) and in this way a great number of young oysters are lifted from the bottom of the oyster beds and spoilt or float away.

The economic importance which the alga has hereby gained, has assuredly been a cooperating factor in its quick discovery. French algologists (Sauvageau, Corbière, L. Mangin and P. Fauvel) found it in 1906—1907 besides at Vannes, at Belle Isle and Quiberon, at Cherbourg and other places in the neighbourhood — then on parts of the S. coast of Brittany and on parts of the N. coast of Normandy, and one of them tells us it was seen in Normandy as early as September 1905. We have no further particulars as to the time, manner and way of its immigration. Still A. D. Cotton (1908, who gives a general account of the plant's immigration) mentions that M. Bornet thinks it has possibly come to the gulf of Morbihan with ships which bring living lobsters from the coasts of Portugal, and from there he supposes it has wandered northwards.

E. M. Holmes and A. D. Cotton found it on the south coast of England in 1907 at Torquay and Swanage (and at any rate it was found fairly plentifully at the first mentioned place), that is to say, between the Isle of Wight and Plymouth. It is possible that in the near future it may be found at many more places on the west coast of France as well as on the south coast of England.

I have gone rather fully into the history of *Colpomenia*'s immigration because I think it has a special interest, partly owing to its economic importance, and partly because it in many ways resembles the history of *B. sinensis*' immigration to the North Sea.

We can sum up our view of *B. sinensis*' immigration in this way: *B. sinensis* appeared suddenly as the main form of the plankton in November 1903 on a small territory of the North Sea, namely, off the west coast of the Jutland Peninsula from the mouth of the Elbe and right into the Skager Rak and

Kattegat; in August 1903 it was not found at all. We may believe that it has been carried along by some ship and has begun reproducing off the mouth of the Elbe from whence it has gone northward and to the north-east with the current. We seem justified in excluding the possibility of an immigration by the current through the English Channel or by the north of Scotland, as it was not found on the coasts of Holland, Belgium or South England, nor at Scotland in August or November; neither is there any reason to believe that it could have come from the Baltic or that it has lived formerly in the North Sea. The immigration must be quite a recent one, though of course one cannot tell the exact time, neither can we say anything definite about the place from which it has come. The greatest possibility is that it has come from the Red Sea or the Indian Ocean or at any rate from that direction.

V. Occurrence and migration in the North Sea during 1904—1907.

A plankton diatom has no proper motion; it is quite without any organ for movements, and the only way in which it might be considered as able to change its position in the water is by the help of its assimilation product: oil, which often appears in the plasma as large refracting drops. As the specific gravity of oil is considerably lower than that of sea water, one can imagine the possibility that a plankton diatom which has for some time lived under specially favourable conditions of assimilation (that is to say, has collected a quantity of oil) could rise from its original place in the water, possibly to a higher layer of water with a lower specific gravity. Whether the alterations which take place in the plasma of the diatom caused by the occurrence of the assimilation oil are so great as to enable the diatom to change its position to other layers of water, we do not know. I am inclined to believe that the alterations are certainly able to move the diatom from its place, ascend or descend, within a fairly homogeneous mass of water, but that they are not able to move to another layer of water (another current), for the simple reason, that the conditions there would be different and would thus affect the diatom in other ways. Meanwhile we cannot at the present either deny or prove this possibility, still I think we may say that it does not belong to ordinary phenomena.

It is quite another thing that the diatoms must be able to change their specific gravity gradually, according to the changes of the mass of water in which they live, as they must be in harmony with the water. If we compare the data for the temperature and salinity — the two factors which determine the specific gravity of the water — at the different places where *B. sinensis* was found in November 1903, we shall find great differences. Let us take for instance the data for the Swedish collections from the Skager Rak (see Tables at the end of the paper). The species occurred in quantities all over the Skager Rak, but there is however an important difference in the occurrence at various places, indeed at some places it was missing altogether. Stat. S. Skag. 3 and S. Skag. 7 shows that it does not do well in over 35 ‰ salinity, whilst S. Skag. 16 and the Danish observations (Da. 12, 15, 18) show that about 20 ‰ is too little for it to thrive in. Between these two figures must consequently lie the optimum of the species as regards the salinity, and everything seems to point to the fact that it lies somewhere nearer 35 ‰ than to 20 ‰ probably between 34 ‰ and 30 ‰. We shall arrive at very similar results regarding the temperature, if we compare the temperature of the different seasons in the Skager Rak with the occurrence of *B. sinensis*.

I have found the under-mentioned approximate figures for the salinity and temperature in relation to *B. sinensis*' occurrence during the whole period for 1903—1907. I distinguish between 1° Maximum and

Minimum for its occurrence at all; as a diatom is able to float in water even when it is dead or dying, and as the plasma does not decay immediately, one cannot instantly determine whether it is dead or alive; — and 2° Maximum or Minimum for a numerous occurrence, that is to say, where it thrives well.

Salinity	Maximum	Minimum
numerous occurrence	c. 35·0 ‰	c. 27·0 ‰ (c. 30·0 ‰)
single „	c. 35·3 ‰	c. 7·5 ‰ [1]
Temperature		
numerous occurrence	c. 12°6	c. 2°2
single „	c. 15°5	c. 1°0

These figures are found in the tables for 1903—1907, but do not claim absolute accuracy, because when one is dealing with comparatively great variations (as here) it is quite immaterial whether there be one decimal more or less. As regards the temperature maxima and minima for a numerous occurrence we ought certainly to add that both are probably too low. No doubt *B. sinensis* will thrive better at a higher temperature than 12°6 C., especially when we compare the high figures which are given for its occurrence on the coast of Guiana and in the Red Sea (see p. 8), but higher temperatures do not occur often in the area in question. On the other hand, it certainly does not thrive well at c. 2°2 C., but the number of species found in water with this temperature may be explained as being the remains of a numerous occurrence at a higher temperature, remains which had not time to disappear as quickly as the temperature sank.

It is evident from this that owing to *B. sinensis*' ability to live in sea-water of widely varying temperature and salinity (it is both eurythermic and euryhaline) it is able to follow the sea current for long distances and whilst the temperature and salinity of the latter are changing considerably. The occurrence of the species in the North Sea and in the adjoining waters during the years 1904—1907 will fully prove this ability. It will in this way — as also other plankton diatoms — have no small importance as an aid to finding out the course of the sea currents. Passively moving plankton-organisms are better objects as "flotteurs" than bottles and pieces of wood which are generally used, as they are not lighter than the current in which they live, which is generally the case with bottles and wood; they will naturally (see however above p. 12) not pass into another current when the one in which they live sinks into a lower depth, as would be the case with bottles and pieces of wood. Many and various experiments have certainly been made to obtain "flotteurs" which have as far as possible the same specific gravity as the water (e. g. Geo. P. Bidder's "Bottom-trailers"); but in any case it is impossible to obtain flotteurs so delicately balanced as a living plankton diatom which can gradually alter its specific gravity with changes in the surrounding water. We shall see on the next page that *B. sinensis* follows the current even when it changes into an under-current. Still there is an important defect in these passively moving plankton organisms regarded as current-indicators, namely, that we in most cases do not know their starting point, and this drawback greatly limits their use. Such a case as the one here mentioned is therefore of special interest, as we know the starting point of the species within the North Sea and can follow its first course. Although it is but a few years since its first occurrence, it is already of slight use as a current-indicator, for by this time it has become stationary in the North Sea, and is consequently of no more use than all other plankton organisms which have been there before it. Its immigration just in the years when the intensive international investigations are procuring such a rich and detailed material has been a fortunate circumstance, which should therefore be utilised to its fullest extent.

[1] Chr. Brockmann (1908, p. 53) has recently reported that the limit for its occurrence in the mouth of the Weser lies between 5 and 6 ‰ ("Die Grenze ihrer Lebensfähigkeit scheint zwischen 0·09 and 0·08 äq. Salzgehalt zu liegen"), which is thus even a little lower than my figures.

The places where *B. sinensis* was found at the four seasonal periods, February, May, August and November, during the years 1904—1906 are shown on the Charts II—IV, and two small Charts in the text give corresponding information for February and May 1907; we are in this way able to follow the development of the species at the different seasons and its migration with the currents in the North Sea region, and on the other side to follow the course of the currents.

1904.

Chart II.

It will be remembered that in November 1903 *B. sinensis* was distributed over a region which extended from the mouth of the Elbe in the south to nearly 4° E. L. towards the west and in the north to the Skager Rak and from there to the north-east, east and south into the Kattegat to ca. 56° 30′ N. L. (off the island of Anholt).

In **February** this region of occurrence has altered, as is shown in the upper chart to the left on Chart II. The southern boundary for the occurrence is still at Heligoland, but both there and at Horns Reef the species only occurs sparsely. It is only when we come to the Skager Rak that it appears in quantity and from there it has wandered with the under-current in through the Kattegat, Great Belt and the Belt Sea to the Cadet Deep (Station D. O. 5); over the whole of the distance from Anholt (Da. 18) southwards it only occurs in the under-current and is only present in small numbers; probably all the specimens occurring there were dying or dead. We have here a fine example of the serviceableness of *B. sinensis* as indicator of a current, all the more difficult to follow as it is an under-current. This is the most distinct evidence we could wish for, that the water-masses of the North Sea penetrate right in to the Baltic through the Great Belt, and several analogous cases are displayed in the following pages.

From the Skager Rak *B. sinensis* has further wandered with the Baltic surface current, which passes southwards round and up along the west coast of Norway. Whereas in November 1903 we did not meet it further north than 58° 10′ N. L., in February 1904 it has reached to 61° 32′ N. L., spreading out at the same time somewhat to the west (to 2° E. L.). It was here found at the two most easterly of the Scottish hydrographical stations (Sc. 7 and 8) mainly in the upper layers — just where the influence of the Baltic current could be marked on the salinity. This occurrence also shows well its importance for the study of the currents. Unfortunately we lack here — as almost always — observations from Norway; we can therefore not follow its migration further to the north and cannot, as in the Baltic, draw any line showing how far it has reached.

In February 1904 *B. sinensis* thus gives us undoubted and certain indications with regard to 1° the part of the North Sea water which penetrates into the Baltic, and 2° the branch of the Jutland current which, mixed with the out-going Baltic current, is continued round the south point of Norway and up along the west coast. We see further, that the species, in spite of the low temperature which we should not expect would suit this warm-water form, occurs in large quantity, though not in such numbers as in November 1903. It is probably no longer in full thriving and certainly the rapidity, with which reproduction (cell-division) proceeds, is considerably less, if in fact there is any division during this cold and dark season. I am more inclined to believe that the development of the species at this season is at a kind of standstill, in the course of which most of the individuals die off and only a small number survive the unfavourable season. No resting stages (endocysts) are known in this species, just as little as in other *Biddulphia* species, so that some of the ordinary cells must presumably remain alive until the next "flowering period".

In **May** 1904 the species has become reduced considerably both in numbers and distribution; this is apparently a very unfavourable season for it; the cold of the preceding winter has only now rightly

succeeded in making its deadly influence felt, the "seasons of the year" as so often in the sea being late. The numerous individuals which were present even in February are greatly decimated and many of those occurring have their plasma more or less destroyed; thus for the three Swedish stations it is stated that they were "dead" (see the Tables). In other words the prosperous season of the species has long past; it is only the last remnants of the autumn maximum period which still float in the water. In none of the samples is the species the predominant form; and the distribution has become considerably restricted though in the main in agreement with that of February. It occurs from the mouth of the Elbe along the west coast of Jutland and into the Skager Rak to the mouth of the Kattegat, further, on the Norwegian Skager Rak coast here and there in the samples and only in small quantity; finally, some few specimens were found in a single sample taken off the west coast of Norway at the same place where it occurred in February (Sc. 8; 61° 25′ N. L.), thus indicating the course of the Baltic-Jutland current along the south and west coast of Norway. It should be remarked that there are Norwegian samples for May 1904 in none of which it did occur; in this way we are able to determine the northern limit for the occurrence of the species for this season.

August. The dying away of the individuals was steadily continued apparently from May to August, and we may thus probably say that with the middle of the summer the last remnants of the autumn maximum had disappeared. This appears distinctly from the chart for August; the species has now quite disappeared from the Skager Rak, only in the Læsø Rende (Da. 12; 57° 24′,8 N. L., 10° 48′ E. L.) were some few specimens found in a single sample; as a matter of fact we often find species at this place which have temporarily disappeared from the neighbouring region but apparently have found here a place of refuge, from which they can again spread out when the right time comes; this is so to speak a nursery for neritic plankton forms.

What is most obvious on the chart for August is, however, that *Bidd. sinensis* is the predominant form of the plankton in the samples from the south-eastern corner of the North Sea off the Elbe and Heligoland; this would mean that a new maximum period is beginning here again, just as in the previous year, only that the production is taking place a little earlier in the year (August, not October); this may be ascribed to a better summer with higher water temperature, but unfortunately I have no data on this.

The interest of the August chart lies chiefly in that it shows the almost complete disappearance of the species from its extensive distribution region in autumn and next the first stage in a new production.

In **November** we again find *B. sinensis* in full process of production, a clear impression of which can be obtained from the last chart on Chart II. The distribution corresponds with quite surprising exactitude to the distribution in November 1903. It seems as if we might draw conclusions from this with regard to the extent of the region, over which the influence of the Jutland current can be traced in autumn, since *B. sinensis* which accompanies this current shows its distribution — or more correctly its minimum distribution. In the west the extreme points are about 4° E. L. and in the east the island of Anholt in the Kattegat; the northern limit (off the Norwegian coast) is as usual unknown.

In addition to this region for its occurrence, November 1904 shows however still another, which was not at all found in November 1903, namely, off the coast of Belgium; here *B. sinensis* was found as a somewhat subordinate component of the plankton at four stations, both in the deeper and in the upper layers, which however are but little different in regard to salinity and temperature (see the Tables), and which belong to one and the same mass of water. The question is now, how has *B. sinensis* come to the Belgian coast?

To answer this question, we must study a little the currents of the North Sea. We known, *inter alia* from T. W. Fulton's investigations (1896), that there is a surface current in circulation in the North Sea, which passes from the Shetlands southwards along the east coast of Scotland and England, until at 54°—53½° N. L. it turns to the east towards the Continental coast opposite the West Frisian Islands and

from there follows the coast in an easterly, north-easterly and northerly direction as far as the Skager Rak; here it divides into two parts, one going into the Kattegat and the other turning towards the south point of Norway, where mixed with the Baltic surface water it proceeds along the southern part of the Norwegian west coast. The portion of the current, namely the north-going current, which proceeds along the Cimbrian peninsula, is the Jutland current so often mentioned in the preceding pages, and the last portion, the mixed current of the Baltic out-going stream and the continuation of the Jutland Current, has also been mentioned several times. Both these portions, as shown in the preceding pages, have undoubtedly and assuredly proved to be transporters of *B. sinensis* in a northerly direction. I must therefore contest C. APSTEIN's statement (1908) that the Jutland current does not carry plankton organisms with it, and I cannot understand on what basis he makes the statement; he says (l. c., p. 50); "Ebenso messe ich dem jütischen Strome keine Bedeutung für das Plankton bei. Er führt nicht die Organismen mit, die wir im Plankton finden, sondern das Plankton ist abhängig von der flachen Küstenbank." One thing in this statement is in my opinion certainly right, namely, that the shallow coastal bank is in high degree favourable to the thriving of the plankton and aids in its rapid production owing to the advantageous outer conditions (warmth, light and abundance of nutriment), but that the Jutland current because it flows so slowly (l. c., p. 49: "der so langsam fliesst"), cannot be of importance for the distribution of the plankton organisms (plankton diatoms) is a statement I cannot understand.

South of the region of the North Sea affected by this circulation current, there is a small part which seems to be relatively independent of the remainder and to stand in close connection with the water-masses of the Channel. MARTIN KNUDSEN (1907, p. 6) states: "The salt water from the Channel and the water-volumes lying between that and the Belgian-Dutch coast form a separate hydrographic region which only gets a comparatively slight water-supply from the other parts of the North Sea", and he refers to P. J. VAN BREEMEN (1903), who has shown that the copepod *Oithona nana* Giesbr. occurs just in this region. The two regions of the North Sea are however not quite altogether independent of one another; current-bottles at any rate, thrown out in the southern region, travel with a current northwards into the Jutland Current; this has been demonstrated by G. GILSON (1901) in his experiments with bottles placed in the water from the West Hinder Lightship. It is natural to say here, that a current goes from the Channel in a northerly and north-easterly direction following the Continental coast to the Skager Rak; how far this current is continuous or not, is another matter which will be discussed below.

The result of this summary of what we know regarding the currents of the North Sea is just this, that we can readily understand by their means the migration of *B. sinensis* northwards from the south-east corner of the North Sea (mouth of the Elbe), but that it would seem impossible for the species to wander from the mouth of the Elbe to the Belgian coast. As it has nevertheless shown itself there in November, we must, unless we suppose another immigration from distant seas by means of ships, since it has not yet been found in the Channel and can naturally not have wandered in from the south, seek for another explanation of this phenomenon if it is at all possible to find one. The simplest hypothesis would be that *B. sinensis* has gradually spread along the coast from the mouth of the Elbe to the west and south, keeping to the eddy lying coastalwards to the north-going current; but this explanation is unfortunately hardly applicable in the present case, since in such a case we should expect to find it at the intermediate places where plankton was taken, thus especially at the Dutch quarterly stations. The form is quite lacking however in the samples taken there, so that the explanation will not do. On the other hand, some of the conditions pointed out by GEO. P. BIDDER (1906) are of interest in this connection. He states (l. c., p. XLI) regarding the coastal current, which runs along the Continental coast, that "it is essentially a winter and spring current, stopped or possibly reversed in the autumn"[1], and according to the examples given "autumn" with him means July and August;

[1] Emphasis by me. C. H. O.

he again returns to this periodic stoppage or reversing of the current when saying (l. c., p. XLII): "a draught in N.E., which probably ceases, or turns[1], in mid-sea (Long. 3°) about midsummer and on the W. Friesland coast in August." BIDDER obtained these results from his experiments with bottom-trailers and they refer consequently mostly to the under-current, but as the southern part of the North Sea has a relatively uniform mass of water from the bottom to the surface, we may venture to consider the results as applicable to the whole water-mass. And starting from the existence of these reversals of the current in early autumn, it seems to me that we have here a somewhat plausible explanation of the sudden appearance of *B. sinensis* on the Belgian coast, even if it is admitted that its absence at all the Dutch stations cannot be explained in this way.

There is another possibility which may also be touched upon briefly, but I do not believe that it can be right. The species might have been carried down from the most northerly stations where it was found, between the Shetlands and Norway, with the south-going current along the east coast of Great Britain, which it has thus followed to the point where the current bends towards the east; here on this supposition it would have been carried over into the true southern parts of the North Sea and thus reached to the Belgian coast. Against this possibility we have: 1° its complexity and the length of the journey, and 2° the fact, that no samples along this extensive distance show the slightest trace of the species, and it would be extraordinary if not a single sample contained it, if it had really come this way, even though the investigations certainly have a great gap between the Scottish and the Dutch stations.

Taking everything into consideration the result of what has been shown above is simply, in my opinion, that we scarcely have sufficient data to finally settle the question, where *B. sinensis* has come from to the Belgian coast in November 1904; we must be content with suppositions and of these I prefer the one mentioned above, based on BIDDER's investigations, namely, that there may be a periodic reversal of the east- and north-going Continental coastal current of the North Sea from a northerly and easterly to a westerly and possibly southerly direction, and that the species has in this way reached from the south-east corner of the North Sea to the Belgian coast.

1905.

Chart III.

The four charts from the seasonal cruises in 1905 show in the main the same features as those we have above learnt for 1904; but there are various points of interest to remark upon. On the whole it occurs more widely distributed and is more frequent in the North Sea in 1905 than in 1904 and 1906.

The **February** chart very closely resembles that for February 1904 and on comparing we find that the few differences are the following:

1° The species has spread out somewhat more to the west (to Stat. D. N. 3 at 3° 16′ E. L.) and is on the whole more abundant in the North Sea than in February 1904.

2° On the other hand the northern stations were it was found are lacking in February 1905, but as the Scottish seasonal cruise was unable to carry out investigations at the most easterly of the Scottish stations (Sc. 7 and 8), we do not know whether the species has been present there, just as little as whether it occurred further north along the Norwegian west coast. In comparison with this it is of no importance that we have no data from the Swedish investigations in the Skager Rak (owing to the death of Prof. CLEVE); as the data to hand from the German and Danish sides permit us to conclude, that in all probability it has also been present where the Swedish seasonal stations lie.

3° Through the Kattegat and the Belt Sea *B. sinensis* can be followed in the lower water-layers (see Stat. Da. 26 and 29 in the Tables), but naturally only as a subordinate component of the plankton. A point of interest where February 1905 differs from February 1904 arises here; the species namely was

[1] Emphasis by me. C. H. O.

found right into the Baltic at the German seasonal station in Dantzig Bay (D. O. 12; 54° 54′ N. L., 19° 15′ E. L.). According to H. Driver (1907, Tables) 180 specimens were found in 1 ccm. in the column of water from 105 to 60 M. and 3 specimens in that from 60 to 0 M.; the last number is so extremely small that we may consider its occurrence to have arisen from an error of some sort; further, Driver states that 11,000 specimens were calculated to be in a column of water of 1 sq. M. surface from 105 to 0 M., — thus on the whole a very small number. Unfortunately nothing is said regarding the cell-contents of the specimens taken; yet we may most probably assume that the most if not all of the cells were dead. The occurrence of *B. sinensis* in the lower water-layers in Dantzig Bay shows us, that this water-layer must have received North Sea water (naturally mixed with Baltic) since November 1904, thus during the winter. This is an agreement with the statements in the summary of the hydrography of the North Sea and adjacent seas, which will be given in the supplementary Bulletin of the International Council (seen in MS.). It is shown there, that the bottom-water in Dantzig Bay is not stagnant water, but must be in comparatively active movement, as it is always warmer than the over-lying water-layers. The inflow of warm water reaches its maximum in winter, which agrees with the appearance of *B. sinensis* in February. O. Krümmel (1904, pp. 30—31) is therefore scarcely correct in saying that this bottom-water is seldom renewed; he states that a renewal has occurred in February 1903, but apparently considers this as very unusual; the investigations of more recent years seem however to show, that the renewal is frequent, though this does not mean regularly every winter. The statement of *B. sinensis* in Dantzig Bay is an absolute proof that a renewal has occurred in the winter of 1904—05 and makes it very probable that the inflowing water has come from the North Sea or Skager Rak.

In **May** the species is widely distributed in the North Sea; to the west it has reached to ca. 2° E. L. (Stat. D. N. 4), but it seems to be lacking off the mouth of the Elbe and from there in a north-westerly direction; it looks as if the water inhabited by *B. sinensis* has withdrawn more to the north. For this month we have also Norwegian plankton collections in the northern part of the North Sea, and these show that *B. sinensis* occurred so far to the north as 63° N. L. (Stat. N. 37), which means right into the Norwegian Sea. It is very interesting that the Baltic-Jutland current has so wide a distribution towards the north that organisms, apparently carried with it, can be found at about 63° N. L. and 2° E. L., where they must meet with Atlantic organisms carried here by the Gulf Stream through the Færoe-Shetland Channel. It is remarkable that *B. sinensis* was not found in the surface water, but in the upper middle layers both at the four Norwegian stations as at the Scottish (see Tables); I can give no explanation of this from the available data. The distribution of the species in May in through the Kattegat and the Belt Sea offers nothing of special interest; it occurs so far in as to the Cadet Deep (D. O. 5), but always — where the samples have permitted the question to be determined — in the lower water-layers only.

August is as usual the minimum period for the species, yet in 1905 it was not so strongly decimated as in 1904; it occurs though in small quantities in not a few of the Skager Rak samples, which thus seems to indicate that it has now become a constant inhabitant of the Skager Rak. In August 1905 flourishing is only beginning in the south-east corner of the North Sea. Of special interest is its occurrence in a sample from 1° 43′ E. L., 55° 7′ N. L., thus almost on the north-west corner of the Dogger Bank; this sample however was not taken in August but on a special German expedition in September (15th); the occurrence here agrees with the above-mentioned stoppage and reversal of the circulation current in the North Sea in the autumn.

In **November** we have again the "flowering period" of the species and in 1905 the chart shows that *B. sinensis* is now one of the dominant forms in the whole of the eastern, shallow-water region of the North Sea from Belgium in the south to the Skager Rak in the north, and also further in the Skager Rak and northern Kattegat; on the other hand, it is still lacking in the western part of the North Sea, that is, it does not occur in the portion of the circulation-current which passes in a southerly direction

along the east coast of Great Britain. Off Belgium it appears in rather large quantities; and on this cruise we find it for the first time off the coast of Holland, namely, common in the sample from 52° 15′ N. L. (Stat. H. 9) and very rare in the sample from 53° 44′ N. L. (H. 2); concerning this last sample Dr. P. J. VAN BREEMEN has informed me by letter that it was taken immediately after the first-named, so that the possibility is thus not altogether excluded that the specimens found were hanging in the meshes of the net and so carried from the one station to the other. It may be therefore, that the gap which was so marked between the occurrence at Belgium and further north in 1904 has not yet completely disappeared in 1905.

Curiously enough the species was not found in the Belt Sea in November 1905; but it was found at a single station (D. O. 8) north of Rügen in the true Baltic (naturally only in the deeper layers and only in small quantity).

1906.

Chart IV.

February. Whilst in 1905 *B. sinensis* was not found at the Belgian coast before November and had thus apparently disappeared for a whole year, from November 1904, in February 1906 remnants of its numbers were found at several of the Belgian stations and also further north at the Dutch station (H. 2) at 53° 44′ N. L. It thus seems now to be stationary also in this southern corner of the North Sea.

In **May** it is as usual rare, but it was nevertheless found in small quantities at several stations which lie far from one another; it gives us the impression that we have here the last remnants of the maximum in November 1905: occasionally some few dead or dying specimens are even now floating whilst the great majority have disappeared by sinking to the bottom or dissolving. Off the Belgian coast it was thus found "floating in midwater" (according to a letter from Prof. GILSON) at a station (B. 1) at 7 miles from the coast. In the north it was met with at the Scottish station (Sc. 7 A) midway between Norway and the Shetlands, and in the south-east the Swedish investigations recorded its presence in the Bornholm Deep (S. O. 5; 55° 26′ N. L., 14° 46′ E. L.), to which it has apparently been carried with the in-going under-current in the period between February and May.

August is still the minimum period for the occurrence of the species; in 1906 it was only found at the two German stations (D. N. 12 and D. N. 15) off the west coast of Jutland; it thus has a distribution which resembles that of August 1904, but in 1906 unfortunately the most important data are lacking, namely from the mouth of the Elbe.

November 1906 offers few novelties. The species has its usual maximum development from the Belgian coast to the Kattegat. Prof. GILSON has informed me by letter that it was already "quite abundant all along the Belgian coast, also in the river Schelde, up to Antwerp" in the beginning of September; the "flowering period" has thus set in very shortly after the August cruises, and the Belgian coast has apparently been the starting-point for the flowering, so far as the southern part of the North Sea is concerned, that is, the species is now stationary there (as already concluded above). It has now spread further out into the open, southern part of the North Sea than before (Stat. H. 3). In the Kattegat it was only found to off the island of Læsø, but the usual station at Anholt is lacking, so that the distribution has most probably been as usual. Its distribution towards the north is also uncertain, as the most eastern Scottish as well as, as usual, the Norwegian investigations are lacking.

1907.

For the year 1907 I have only been able to obtain data on the distribution of *B. sinensis* for the first two seasonal cruises, and this information is shown on the two charts reproduced here in the text.

February shows the interesting point, that the species occurs much further to the west in the northern part of the North Sea than before known, namely, at the Scottish stations Sc. 22 (0° 41′ W. L.), 23 (0° 37′ E. L.) and 24 (0° 04′ E. L.), at all three stations in the upper water-layers, and this occurrence shows us that the Baltic-Jutland surface current has at this time had quite an unusual distribution to the west and has quite excluded on the surface the in-coming water between Scotland and Norway.

For the rest, the distribution in February 1907 is just as usual, namely, almost the same as in the maximum period in November, but everywhere in considerably smaller numbers and always penetrating further in into the Baltic. This time its furthest-in point lies north of Rügen (D. O. 8). The occurrence here in the Baltic obviously stands in connection with the fact, that the in-going under-current with salt water has its maximum period during the winter and spring.

Fig. 4. Distribution of *Biddulphia sinensis* in February 1907 (Signs are to be understood as in the charts).

May is only remarkable for the circumstance, that an unusually large number of *B. sinensis* still remain, even if the quantity is considerably reduced in comparison with February.

Résumé. During the years 1904—07 *B. sinensis* has become stationary in the North Sea; it has found refuge places suited to it in certain areas, from which every year in late autumn (September-November) it shoots up and spreads out with the currents. The earliest refuge or nursery place was off the mouth of the Elbe and next probably the shallow-water part of the Skager Rak; further, it appeared on the Belgian coast in November 1904 and since then has had a centre there. The development obviously proceeds in such a way, that the whole of the shallow-water, Continental coast of the North Sea must be a home for the species.

During the past years it has appeared each year at its maximum period in November in such quantities, that it has been one of the dominant forms of the plankton[1]. No resting-stages have hitherto been found of this species, and probably it passes the unfavourable period in its usual form, most of the cells dying but a few remaining alive.

From the new home for the species here indicated, it has spread with the currents far beyond this region, thus, towards the north and north-west with the surface current out into the Norwegian Sea and almost to the Shetlands, towards the south and east with the under-current in through the Belt Sea and into the Baltic as far as Dantzig Bay. On these wanderings the species has not succeeded in fixing itself in these regions, as the salinity and temperature — the outer conditions as a whole — have not been suitable for it.

That a plankton organism can also exceptionally go against the direction an oceanic current is

[1] 4140000 cells in 1 m³ water at Stat. D. N. 15, Nov. 1903 (C. Apstein, 1905)!

supposed to have, is shown by the sudden appearance of the species at the Belgian coasts in November 1904. This only means naturally, that the direction of a current is usually given according to the sum of the available investigations, that is, the normal and not the exceptional is indicated; the species has naturally not made its way actively against the current, but has accompanied this, which at a certain period has had a direction different from the ordinary.

It is remarkable that the species has not even yet reached the coasts of the Channel, in spite of the fact, which G. GILSON states in February 1907, that it "seems to be quite acclimatised on our (Belgian) coast". It is to be noted on all the charts that the species was not found in the Channel at the stations lying nearest to the North Sea, and I may add that it is not known either from more westerly stations in the Channel. That in the course of a few years the species will wander southwards along the coast, is both reasonable and probable. Up till 1908 however it has not reached far, as appears from some interesting information placed at my disposal by Prof. G. GILSON and which I may give here: "On May of this year (1908), I went south down to Boulogne, remaining close to the shore all the way along and taking samples of plankton every half hour. *B. sinensis* was found all the way up to the small fishing harbour of Gravelines. After that it completely disappeared. On the way back to Ostend, the same work was done again and *B. sinensis* appeared again for the first time off Gravelines." It appears from this that the progress southwards of *B. sinensis* is slow.

Fig. 5. Distribution of *Biddulphia sinensis* in May 1907.

VI. General remarks on the relation to temperature and salinity; importance for the investigations on the rapidity of flow of the currents.

It has been repeatedly shown in the fore-going chapter that *B. sinensis* might be used to follow and to determine the distribution and direction of the oceanic currents. The species seems to be specially suited for this purpose, in as much as it is very wide in its demands as regards temperature and salinity; an organism which can only thrive in water of a very definite temperature and salinity or in water which only varies within narrow limits — stenothermic and stenohaline as K. MÖBIUS has called

it in contrast to eurythermic and euryhaline — would not be nearly so useful as current-indicator in the coastal waters in question here. The sea-currents near the coast are in fact exposed to relatively great variations in their temperature and salinity on account of the outflow of fresh or brackish water, and a sensitive organism will very quickly die under such conditions.

The numbers given above (p. 13) for the range of variation in regard to temperature and salinity of *B. sinensis* show best its great adaptibility. CHR. BROCKMANN (1906 and 1908) has made a number of investigations on the effect of the brackish water on the plankton in the mouth of the Weser, and he comes to the result, that *B. sinensis* belongs to the marine species which are less sensitive towards a decrease in salinity and which can thus live in brackish water. It will certainly prove on the whole that C. APSTEIN (1908, p. 50) is correct in stating: "kleinere Differenzen in Salzgehalt und Temperatur hindern die Organismen nicht an der Ausbreituug. Sie reagiren nur auf grobe hydrographische Unterschiede und auch dann nicht immer, wenn die Änderung allmählich stattfindet." I believe that we may add, that this applies specially to the organisms of the coastal plankton (the neritic plankton), which are generally much more euryhaline and eurythermic than the oceanic plankton forms. This is naturally in connection with the fact, that the plankton at the coasts is much more frequently exposed to changes in the temperature and salinity of the water than out in the open ocean, which is remarkable for its uniformity. Thus, whilst differences under 1 per mille in the salinity out in the North Atlantic may constitute determinating limits for the momentary distribution of the plankton organisms, such a difference would be quite without importance for the plankton in the North Sea and its branches. The many data in the Tables on the temperature and salinity at the places where *B. sinensis* was found show this with sufficient clearness. It must be remembered however, what has already been mentioned several times, that the presence of specimens of *B. sinensis* in a plankton sample does not indicate that the species can live there, but only that the current has carried specimens with it which perhaps have long been dead, but which on account of their floating power have not yet sunk to the bottom. From a biological standpoint this means, that we may not conclude from the occurrence of such a species in a plankton sample, that the species in question lives there, where the sample was taken; and in our special case with *B. sinensis* it further means that the true distribution, to which it has attained during the past years within the North Sea territory, is of considerably less extent than the areas for which it has been recorded in that time. Regarding the matter from a hydrographical standpoint, however, it is indifferent whether a species in a plankton sample is living or dead, as it shows just as well (or as little) where the current which carries it comes from. In the case of *B. sinensis*, its importance as indicator for the under-current in through the Belt Sea and into the Baltic is just as great, even though the specimens found in the Baltic were dying or dead, at least quite unable to continue the existence of the species.

The same thing holds good, if we endeavour to utilise the migrations of *B. sinensis* with the currents to calculate the rate of flow of the latter; it is quite indifferent whether the specimens are living or dead. If we wish to obtain exact results regarding the velocity of the current from the occurrence or non-occurrence of plankton organisms, we must have daily plankton collections from a number of different places within the region to be investigated. At present, however, we do not have this, and such a material would also be so enormous, that its working up would be impossible. On the other hand, the material from the seasonal cruises, which is collected at ca. 3 months intervals, is very little suited to a study of the currents. The material I have obtained from fortnightly collections at Danish light-ships is considerably better, though naturally far from good. The numbers to be obtained from calculations from these collections give a "maximum" velocity, which differ by half a month. If we have for example the following data: at the Horns Reef light-ship the species was not found in the plankton on October 1st, but on the 15th and at the Skagens Reef light-ship neither on the 1st or 15th October, but first on the 2nd of November, we can only know that it came to the Horns Reef between the 2nd

and the 15th, and to the Skagens Reef between the 16th October and the 2nd of November, but not the exact date. To be on the safe side we must therefore calculate with the extreme numbers on both sides and consequently say, that it may have come to the Horns Reef on October 2nd and to Skagens Reef on November 2nd, i. e. that it may have been 32 days on the way; from this we thus find a minimum value for the rate of flow, when we know the distance between the two places. The "maximum" we find by taking the period in the example between October 15th and November 2nd, i. e. 19 days, since there is the possibility that the species first came to Horns Reef on October 15th and from there reached to Skagens Reef on November 2nd; but I do not lay any great weight on this "maximum" value, as it is not the true maximum rate of flow, since the species might possibly have reached to Skagens Reef some time before the 2nd of November (but naturally after October 15th).

Biddulphia sinensis Grev.

Danish Light-Ships	1903						1904									
	October		November		December		January		February		March		April		May	
	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
North Sea Horns Rev (28—0 M.) 55° 34′ N. Lat., 7° 19′5 E. Long.	.. / ÷	.. / cc	(2) / cc	(16) / cc	(3) / cc	(14) / cc	(4) / cc	(14) / c	.. / c	.. / r	(3) / r	(17) / ÷	(4) / ÷	(14) / rr	.. / —[1]	—
Skager Rak Skagens Rev (38—0 M.) 57° 46′ N. Lat., 10° 43′3 E. Long.	.. / ÷	.. / ÷	(2) / cc	.. / cc	.. / cc	.. / +	.. / +	(18) / cc	.. / cc	.. / c	(3) / r	(17) / r	(4) / rr	(18) / rr	(2) / rr	(16) / rr
Kattegat Læsø Rende (21—0 M.) 57° 12′8 N. Lat., 10° 41′7 E. Long.	.. / ..	.. / ÷	(2) / r	.. / —	.. / —	.. / —	.. / —	.. / —	.. / —	.. / c	(3) / r	(17) / rr	(4) / rr	.. / —	.. / —	—
Kattegat Anholt Knob (28—0 M.) 56° 46′ N. Lat., 11° 51′8 E. Long.	.. / ..	.. / ÷	(2) / rr	(16) / r	(3) / r	(17) / r	.. / —	.. / —								
Kattegat Schultz's Grund (26—0 M.) 56° 08′9 N. Lat., 11° 11′2 E. Long.	.. / ..	.. / ..	.. / ÷	.. / ÷	(3) / rr	(14) / rr	.. / —	.. / —								

[1] — denotes, that samples from this date have not been examined. The others signs are to be understood in the ordinary manner.

The accompanying Table gives a number of data for the occurrence of *B. sinensis* at Danish light-ships in the winter of 1903—1904. Samples were taken at the beginning and in the middle of the month at each light-ship and at the head of the table the dates 1st and 15th are noted for the sample, but as a matter of fact the day of collection often differed one or a few days from these dates, and I have therefore given in brackets above the sign of frequency the actual dates for the samples, so far as they differed from the normal. The position of the five light-ships mentioned is as follows: the Horns Reef lies on the west coast of Jutland, thus in the North Sea, Skagens Reef lies in the Skager Rak at the entrance to the Kattegat, and Læsø Rende, Anholt Knob and Schultz's Grund lie in the Kattegat almost in a direction from north to south. The Table shows that *B. sinensis* appeared for the first time at Horns Reef on the 15th of October 1903, at Skagens Reef, Læsø Rende and Anholt Knob on November 2nd 1903 and at Schultz's Grund on December 3rd 1903. To these data we may add a few more from P. T. Cleve's last report (1905) on the plankton at the two Swedish coastal stations in Bohuslän, Måseskär (58° 6′ N. L.) and Väderöbod (58° 37′ N. L.); we find it stated there that *B. sinensis* was for the first time

observed during the week 20th—28th and 19th—30th October 1903 respectively[1]. If we use the data given, we can make the following calculations:

(1) Horns Reef; *B. sinensis* not present on October 1st, present October 15th, thus possibly present October 2nd. Måseskär, not present Oktober 19th, present at any rate October 28th. The greatest difference in time is from October 2nd to October 28th = 27 days. The distance from Horns Reef to Måseskär is ca. 215 nautical miles, so that the minimum rate of flow for the Jutland current in October 1903 was ca. 8 nautical miles per day (= ca. 17·2 cm. per second).

(2) Horns Reef; as above. Anholt Knob; not present October 15th, present November 2nd. The greatest difference in time is from October 2nd to November 2nd = 32 days. The distance from Horns Reef past the Skaw (Skagen) to Anholt Knob is ca. 255 nautical miles, so that we have the same result from this calculation, namely that, the minimum rate of flow of the Jutland current, including therewith the under-current penetrating into the Kattegat, was in October 1903 ca. 8 nautical miles per day (= ca. 17·2 cm. per second).

(3) Anholt Knob; *B. sinensis* not present October 15th, present November 2nd; as it was still absent at Måseskär on October 19th, it has certainly not been at Anholt Knob before at the earliest October 20th. Schultz's Grund; not present November 15th, present December 3rd. The greatest difference in time is thus from October 20th to December 3rd = 45 days. The distance between Anholt Knob and Schultz's Grund is ca. 43 nautical miles and we thus find, that the under-current in November 1903 in the southern part of the Kattegat has been flowing in with a minimum rate of flow of nearly 1 nautical mile per day (= ca. 2·15 cm. per second).

(4) Schultz's Grund; as above, thus present at the earliest November 16th 1903. At the German Baltic Station D. O. 5 it was found on the seasonal cruise on February 11th 1904. The greatest difference in time is from November 16th 1903 to February 11th 1904 = 88 days. The distance from Schultz's Grund through the Great Belt to D. O. 5. (Cadet Deep) is ca. 135 nautical miles, and we thus find here that the minimum rate of flow of the under-current through the Great Belt, Langeland Belt and Fehmarn Belt to Cadet Deep was ca. 1·5 nautical miles per day (= ca. 3·22 cm. per second).

Comparing other statements of the rate of flow with these numbers, all of which deal with the minimum rate, as I have not considered it worth the trouble to give the "maximum", though it might easily be calculated (e. g. it is 29 and 33 cm. per sec. in the first and second cases), we find that our knowledge of these phenomena is still very small. In the "Nautical Meteorological Annual" published by the Danish Meteorological Institute, we find measurements given of the currents at the Danish light-ships; these are made 6 times daily, but naturally only give the rate of flow and direction of the current at the moment of measuring; they thus do not say anything about the resultant velocity, which really carries the water-masses away in one direction or another. For example, we find given for the average rate of flow at Horns Reef in October 1903 1·4 nautical miles per hour, with a direction mostly from S. S. E. If we consider all the data on the southern half of the compass as positive and those on the northern half as negative, we reduce the average rate of flow to ca. 1·0 nautical mile per hour in October 1903, thus 24 nautical miles per day (= 51·5 cm. per second). This agrees with B. Helland-Hansen's statement (1907, p. 27) that a measurement of the current off Hirtshals light-ship on 30/31 July 1906 gave an average rate of flow of 45 cm. per second in the upper water-layers. These numbers are considerably higher than those calculated from the migration of *B. sinensis*, but it must be remembered that the rate of flow of the current varies considerably over the long distance between Horns Reef and Måseskär or Anholt Knob, and that all these numbers were found from measurements which only lasted a very short time, whilst the numbers calculated from the migrations of *B. sinensis* give the minimum

[1] "Samples having been collected 3 to 4 times a month" (Cleve, l. c.).

rate for the current's true progress. Further, Cand. J. P. JACOBSEN has kindly informed me that he has calculated the annual average rate of flow for Horns Reef for the ten years 1898—1907 to be ca. 40 cm. per second for the north-going current and ca. 20 cm. per second for the south-going, the resultant of which gives ca. 20 cm. per second in a north-going direction, which agrees exceedingly well with our number 17·2 cm. per second.[1]

I have nothing to compare with the above calculated minimum rate of flow of the under-current in the Southern Kattegat and through the Great Belt to Cadet Deep, namely 2·15 and 3·22 cm. per second respectively, firstly and chiefly because the in-going current according to both MARTIN KNUDSEN (1899) and OTTO PETTERSSON (1908) is an intermittent current, thus not a continuous stream, so that momentary observations of the rate of flow cannot in the least be compared with our calculations, which are the result of 1½ and 3 months' inflow respectively.

As mentioned above, the seasonal observations, on account of the wide intervals of 3 months between each, are not suited to the calculation of the rate of flow, but I may just mention, that an approximate idea of the rate of flow can nevertheless be obtained by calculating the above-mentioned "maximum", as for example, when we find that *B. sinensis* was present at the German North Sea Station D. N. 8 (58° 19′ N. L., 5° 43′ E. L.) on November 7th 1903 and at the Scottish Station Sc. 8 (61° 32′ N. L., 3° 10′ E. L.) on February 19th 1904; the distance between the two stations is 210 nautical miles, which, if we assume that *B. sinensis* on November 7th 1903 had only reached to D. N. 8 and no further, and only to Sc. 8 on February 19th 1904, gives a rate of ca. 2 nautical miles per day (= ca. 4·3 cm. per second) for the surface-current off West-Norway. An analogous calculation for the Baltic is as follows: *B. sinensis* was present in the Kattegat at Da. 18 (56° 47′ N. L., 11° 47′ E. L.) on November 1th 1904 and in Danzig Bay at D. O. 12 (54° 54′ N. L., 19° 15′ E. L.) on February 5th 1905; the distance between these stations is 520 nautical miles, which gives a "maximum" rate of flow for the under-current of 5·36 nautical miles per day (= 11·5 cm. per second); but regarding this last example especially it may be said, that we know absolutely nothing as to how far into the Belt Sea and Baltic *B. sinensis* had reached in November 1904, and that the specimens which were found in Dantzig Bay in February 1905 possibly came from an earlier immigration, so that this calculation is of extremely little value.

All things considered it may be said, that *B. sinensis* during its first immigration in 1903—1904 could actually be employed in some cases for the calculation of the lowest value of the rate of flow of the Jutland current into the Skager Rak and likewise for the calculation of its continuation in the lower water-layers as an under-current through the Kattegat and Belt Sea. The minimum rate of flow along the west coast of Jutland and in the Skager Rak and Northern Kattegat has thus been calculated to be ca. 17 cm. per second, in the Southern Kattegat (under-current) 2·15 cm. per second and in the Belt Sea (under-current) 3·22 cm. per second.

The aim of the present paper has been to follow the immigration of *B. sinensis* and to show its importance for hydrography as a means of determining the direction and rate of flow of the oceanic currents; an endeavour has also been made to picture the outer conditions under which the immigration of this form has successfully proceeded right before our eyes; in 1903—1907 the North Sea has become richer by a plankton-diatom which is of importance for the general characterisation of its plankton.

Copenhagen, October 1st, 1908.

[1] I am unable to find where O. KRÜMMEL (1904, p. 13) has obtained 4 nautical miles per day (8·6 cm. per second) for the average annual rate of flow of the current at Horns Reef.

VII. Tables.

The Tables contain all the data on the occurrence of *Bidd. sinensis* in the North Sea and adjacent seas in the years 1903—07, which could be obtained from the "Bulletin des resultats etc." and "Bulletin trimestriel etc."; further, some stations where it did not occur are also included, where they seemed to be of interest for the study of the continuity in its distribution; lastly, at several places information has been included from elsewhere, naturally with acknowledgement of where the data come from. For each sample is stated, as far as possible, the position of the Station, date, depths (where nothing special is noted, this means vertical hauls or horizontal hauls at the surface), the temperature of the water and salinity, as also the estimated frequency of *Bidd. sinensis*, all taken from the Bulletin.

I. November 1903

1. North Sea. Germany

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
DN Elbe Lightship	0	—	—	c [1]
DN Heligoland	0	—	—	c
DN 1 54°41′ N. Lat. 6°12′ E. Long. 1903 XI 4	38—0	12°12—12°09	34·51—34·60	rr [302] [2]
	0	12°09	34·60	+
DN 2 55°22′ N. Lat. 4°18′ E. Long. 1903 XI 5	42—0	11°38—11°44	34·80—34·90	rr [400]
	0	11°44	34·90	rr
DN 3 56°02′ N. Lat. 3°16′ E. Long. 1903 XI 5	—	—	—	÷
DN 4 56°41′ N. Lat. 2°15′ E. Long. 1903 XI 6	—	—	—	÷
DN 5 57°24′ N. Lat. 3°41′ E. Long. 1903 XI 6	—	—	—	÷
DN 6 57°54′ N. Lat. 4°48′ E. Long. 1903 XI 6	98—75	7°78—7°78	35·19—35·19	rr [104]
	75—5	7°78—9°28	35·19—31·71	r [1140]
	5—0	9°28—9°39	31·71—31·79	+ [22400]
DN 7 58°08′ N. Lat. 5°19′ E. Long. 1903 XI 7	270—5	6°36—9°22	35·19—28·19	r
	5—0	9°22—9°29	28·19—28·22	+
	0	9°29	28·22	+
DN 8 58°19′ N. Lat. 5°43′ E. Long. 1903 XI 7	315—150	6°12—6°98	35·13—35·07	(rr) [3] [25]
	150—80	6°98—10°68	35·07—34·34	(rr) [3] [580]
	80—5	10°68—9°08	34·34—26·75	r [6400]
	5—0	9°08—9°19	26·75—26·68	+ [80000]
	0	9°19	26·68	+
DN Mandal 1903 XI 8	0	—	—	c
DN 9 57°52′ N. Lat. 7°20′ E. Long. 1903 XI 11	0	—	—	cc
DN 10 57°32′ N. Lat. 7°36′ E. Long. 1903 XI 11	0	9°29	31·34	+
DN 11 57°17′ N. Lat. 7°47′ E. Long. 1903 XI 11	0	9°29	32·95	+
DN 12 a 56°56′ N. Lat. 7°41′ E. Long. 1903 XI 11.	0	—	—	rr
DN 15 55°02′ N. Lat. 7°30′ E. Long. 1903 XI 12	22—0	10°39—10°24	33·35—33·36	cc [4140000]
	0	10°24	33·36	cc
DN Heligoland 1903 XI 12	0	—	—	cc

[1] The symbols for the frequency indicate the following: cc = very common. c = common. + = not uncommon. r = rather rare. rr = very rare. × = present. ÷ = absent.

[2] The number in 1 m³ water, reckoned by C. Apstein, 1905.

[3] «meist leer».

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
2. Skager Rak. Sweden				
S 5				
57°42′ N. Lat.	50—0	10°88—9°00	34·09—32·20	cc
9°51′ E. Long.	20—0	9°88—9°00	32·99—32·20	cc
1903 XI 12	0	9°00	32·20	cc
S 6				
57°56′ N. Lat.	130—30	7°62—10°50	35·19—34·47	r
9°40′ E. Long	30—0	10°50—8°2	34·47—30·25	cc
1903 XI 12	0	8°2	30·25	cc
S 8				
58°10′ N. Lat.	600—0	5°43—8°3	35·39—30·12	c
9°18′ E. Long.	100—30	6°80—10°16	35·34—34·58	c
1903 XI 12	30—0	10°16—8°3	34·58—30·12	cc
	0	8°3	30·12	cc
S 9				
58°21′ N. Lat.	200—0	7°13—8°0	35·07—27·94	cc
8°56′ E. Long.	0	8°0	27·94	c
1903 XI 12				
S 13				
58°36′ N. Lat.	200—60	6°96—12°29	35·25—34 60	cc
9°20′ E. Long.	60—0	12°29—7°9	34·60—27·61	cc
1903 XI 13	0	7°9	27·61	+
S 7				
58°26′ N. Lat.	600—300	5°49—6°26	35 08—35·14	r
9°44′ E. Long.	100—40	6°94—10°47	35·07—34·67	—
1903 XI 13	40—0	10°47—8°7	34·67—30·77	cc
	0	8°7	30·77	cc
S 10				
58°48′ N. Lat.	150—0	7°77—8°5	34·94—31·11	cc
10°25′ E. Long.	0	8°5	31·11	cc
1903 XI 14				
S 14				
58°49′,6 N. Lat.	220—100	6°26—9°49	34·87—34·49	cc
11°05′,7 E. Long.	100—40	9°49—10°77	34·49—32·77	cc
1903 XI 15	40—0	10°77—7°8	32·77—29·00	cc
	0	7°8	29·00	cc
S 3				
58°12′ N. Lat.	200—100	7°17—7°10	35·21—35·14	—
10°29′ E. Long.	100—20	7°10—11°03	35·14—34·14	r
1903 XI 13	20—0	11°03—8°6	34·14—30·66	cc
	0	8°6	30·66	cc
S 1				
58°03′ N. Lat.	200—20	7°62—10°49	35·39—34·11	+
10°48′ E. Long	20—0	10°49—8°4	34·11—30·99	cc
1903 XI 14	0	8°4	30·99	cc
S 2				
57°53′ N. Lat.	130—60	8°68—11°14	34·96—34·69	r
10°42′ E. Long.	60—30	11°14—11°77	34·69—34·54	+
1903 XI 11	30—0	11°77—8°8	34·54—30·82	cc
	0	8°8	30·82	cc

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S 4				
58°13′ N. Lat.	115—0	7°86—8°3	35·01—31·00	cc
11°00′ E. Long.	0	8°3	31·00	cc
1903 XI 14				
S 15				
58°15′,8 N. Lat.	50—25	10°70-[10°65][1]	33·21—[32·50]	cc
11°26′,8 E. Long.	25—0	[10°65] – 7°3	[32·50]—28·12	cc
1903 XI 15	0	7°3	28·12	cc
S 16				
58°19′,3 N. Lat.	110—50	5°94—10°48	34·54—33·57	cc
11°32′,6 E. Long.	50—0	10°48—5°3	33·57—20·03	cc
1903 XI 16	0	5°3	20·03	r
S 17				
58°23′,1 N Lat.	35—20	10°91—10°66	32·84—32·16	+
11°34′,7 E. Long.	20—0	10°66—5°0	32·16—18·95	cc
1903 XI 16				
S 0				
57°41′ N. Lat.	70—50	10°97—11°31	34·13—33·75	cc
11°23′ E. Long.	50—0	11°31—9°8	33·75 – [c. 25·0]	cc
1903 XI 9	0	9°8	[c. 25·0]	cc

3. North Sea. Surface

Samples collected from Swedish steamers; the information kindly sent me by the late Professor Cleve.

Station	Frequency	Station	Frequency
57°23′ N. Lat. 5°37′ E Long. 1903 XI 6	r	57°54′ N. Lat. 9°22′ E. Long. 1903 XI 6	+
57°42′ N. Lat. 6°56′ E. Long. 1903 XI 6	cc	57°32′ N. Lat. 9°40′ E. Long. 1903 XI 6	cc
57°50′ N. Lat. 8°16′ E. Long. 1903 XI 6	+	57°36′ N. Lat. 9°44′ E. Long. 1903 XI 7	cc
57°03′ N. Lat. 8°02′ E. Long. 1903 XI 7	+	57°46′ N Lat. 10°41′ E. Long. 1903 XI 14	+
57°18′ N. Lat. 8°58′ E Long. 1903 XI 14	+		

[1]) The figures in brackets found by interpolation.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
4. Skager Rak and Kattegat. Denmark				
Da 4				
57°57′,7 N. Lat.	150—50	11°15—11°55	34·52—33·73	c
10°49′,6 E. Long.	40—0	11°2—10°5	33·37—32·68	cc
1903 XI 1				
Da 7				
57°52′ N. Lat.	85—70	9°5—[c. 10°]	34·11—[32·50]	cc
11°18′ E. Long.	60—40	[c. 11°]—10°3	[c. 32·00]-30·41	cc
1903 XI 1	20—0	9°6—9°3	26·47—24·78	÷
Da 9[1]				
57°41′ N. Lat.	80—40	9°2—10°1	33·95—29·13	c
11°23′ E. Long.	30—0	9°8—9°1	27·70—22·09	+
1903 XI 1				
Da 12				
57°24′,8 N. Lat.	40—20	10°2—9°7	31·46—25·72	c[2]
10°48′ E. Long	15—0	9°25—9°05	22·54—20 80	÷
1903 XI 2				
Da 15				
55°17′,9 N. Lat.	60—0	10°10—8°7	34·49—20·61	rr
11°27′,4 E. Long.	40—20	9°8—9°96	33·96—31·42	+
1903 XI 1	15—0	8°85—8°7	21·51—20·61	÷
Da 18				
56°47′,3 N. Lat.	40—0	11°14—8°6	33 64—18·39	rr
11°47′ E. Long.	35—20	[c. 11°]—10°72	[33·46]—32·66	rr
1903 XI 1	10—0	9°12—8°6	20·50—18·39	÷
Da 20				
56°22′,3 N. Lat.	28—0	10°86—8°6	34·05—18·31	÷
11°48′,6 E. Long.				
1903 XI 1				

Then absent at all more southerly stations.

II. February 1904

1. North Sea. Germany

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
DN Heligoland	0	—	—	÷
DN 1				
54°42′ N. Lat.	30—0	4°59—4°59	34·63—34·60	÷
6°12′ E. Long.	0	4°59	34·60	÷
1904 I 29				
DN 3				
56°02′ N. Lat.	0	—	—	÷
3°16′ E. Long.				
1904 I 30				
DN Egersund	0	—	—	c
DN Lister	20—0	—	—	+
	0	—	—	c
DN Kleven (Mandal)	0	—	—	c
DN 9 a[3]	0	—	—	+
DN 10 a[3]	0	—	—	r
DN 11 a[3]	0	—	—	r
DN 12 a[3]	0	—	—	÷
DN 12—14	0	—	—	r
DN 14				
56°13′ N. Lat.	28—0	4°10—4°14	34·67—34·66	rr
7°21′ E. Long.	0	4°14	34·66	r
1904 II 5				
DN 15				
55°02′ N. Lat.	27—0	3°59—3°59	34·33—34·24	r
7°30′ E. Long.	0	3°59	34·24	r
1904 II 6				
DN Heligoland	0	—	—	r

2. North Sea. Scotland

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
Sc 7				
61°09′ N. Lat.	100—0	7°56—5°73	35·26—33·98	rr
2°00′ E. Long.	0	5°73	33·98	+
1904 II 19				
Sc 8				
61°32′ N. Lat.	100—0	6°67—5°65	34·72—34·02	+
3°10′ E. Long.	0	5°65	34·02	+
1904 II 19				

Absent at all the other stations.

3. Skager Rak. Sweden

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S 5				
57°42′ N. Lat.	60—0	3°16—2°5	34 74—34·07	c
9°51′ E Long.	0	2°5	34·07	c
1904 II 16				
S 6				
57°56′ N. Lat.	40—0	4°17—3°4	34·58—33·71	rr
9°40′ E. Long.	0	3°4	33·71	÷
1904 II 16				
S 8				
58°10′ N. Lat.	100—0	6°64—2°3	34·92—30·46	c
9°18′ E Long.				
1904 II 16				
S 9				
58°21′ N. Lat.	150—75	6°45—6°24	34·92—34·78	c
8°56′ E. Long.	75—0	6°24—0°5	34·78—27·68	c
1904 II 17				

[1]) = Stat. S 0. [2]) Most of the specimens dead. [3]) Owing to bad weather the position of the stations is incertain, and it was impossible to get data for salinity and temperature.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S 14				
58°49′,6 N Lat.	200—100	5°83—5°84	34·76—34·69	+
11°05′,7 E. Long.	200—0	5°83—0°4	34·76—27·11	+
1904 II 18	100—0	5°84—0°4	34·69—27·11	c
S 3				
58°12′ N. Lat.	140—100	6°72—6°52	35·10—34·99	+
10°29′ E. Long.	140—0	6°72—3°7	35·10—31·94	cc
1904 II 15	100—50	6°52—5°04	34·99—34·42	c
	50—0	5°04—3°7	34·42—31·94	cc
	0	3°7	31·94	cc
S 1				
58°03′ N. Lat.	150—60	6°70—6°58	35·14—34·79	cc
10°48′ E. Long.	60—30	6°58—4°90	34·79—34·09	c
1904 II 16	30—0	4°90—2°0	34·09—28·78	cc
S 2				
57°53′ N. Lat.	100—0	5°73—2°8	34·85—30·52	+
10°42′ E. Long.	50—0	5°69—2°8	34·96—30·52	+
1904 II 16				
S 4				
58°13′ N. Lat.	100—50	5°08—5°12	34·76—34·74	cc
11°00′ E. Long.	100—0	5°08—4°0	34·76—32·45	cc
1904 II 15	50—0	5°12—4°0	34·74—32·45	cc
	0	4°0	32·45	cc
S 15				
58°15′,8 N. Lat.	50—0	4°90—2°4	34·16—29·42	c
11°26′,8 E. Long.				
1904 II 19				
S 16				
58°19′,3 N. Lat.	100—40	5°64—5°22	34·43—34·02	+
11°32′,6 E. Long.	100—0	5°64—1°8	34·43—27·74	+
1904 II 19	40—0	5°22—1°8	34·02—27·74	c

4. Skager Rak, Kattegat and Belt Sea. Denmark

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
Da 4				
57°57′,7 N. Lat.	200—0	—2°6	—27·99	c
10°49′,6 E. Long.				
1904 II 2				
Da 7				
57°52′ N. Lat.	94—65	5°42—[5°0]	34·65—[33·65]	c
11°18′ E. Long.	94—0	5°42—2°2	34·65—27·65	c
1904 II 1	20—0	2°88—2°2	30·53—27·65	+
Da 9				
57°41′ N. Lat.	75—0	5°22—2°0	34·56—26·46	c
10°23′ E. Long.	30—0	2°90—2°0	30·14—26·46	r
1904 II 1				
Da 12				
57°24′,8 N. Lat	30—20	3°90—3°66	32.70—32·41	c
10°48′ E. Long.	30—0	3°90—2°6	32·70—27·16	c
1904 II 3	10—0	3°04—2°6	27·52—27·16	+
Da 15				
57°17′,9 N. Lat.	60—20	5°0—2°4	34·11—25·34	c
11°27′,4 E. Long.	10—0	2°2—1°7	23·60—22·23	r
1904 II 2				
Da 18				
56°47′,3 N. Lat.	33—15	4°8—4°1	32·97—30·90	+
11°47′ E. Long.	10—0	1°6—1°1	21·46—20·61	÷
1904 II 2				
Da 20				
56°22′,3 N. Lat.	20—0	6°5—1°2	33·04—18·60	rr
11°48′,6 E. Long.	0	1°2	18·60	÷
1904 II 3				
Da 21				
56°07′,9 N. Lat.	30—20	6°9—6°8	33·71—33·49	rr
11°11′,1 E. Long.	10—0	2°2—2°1	21·53—21·47	÷
1904 II 3	0	2°1	21·47	÷
Da 23				
55°46′,7 N. Lat.	35—0	5°58—2°5	31·00—21·08	rr
10°48′,8 E. Long.				
1904 II 1				
Da 26				
55°20′,4 N. Lat.	50—0	6°15—1°7	31·82—17·63	rr
11°02′,3 E. Long.				
1904 II 1				
Da 29				
55°01′,5 N. Lat.	25—0	2°8—1°5	25·35—15·14	÷
11°02′,2 E. Long.	18—0	[1°9]—1°5	[16·35]—15·14	÷
1904 II 2				
Da 32				
54°35′,5 N. Lat.	30—0	3°62—1°5	23·21—15·35	rr
11°03′,5 E. Long.				
1904 II 2				

5. Belt Sea. Germany

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
DO 1				
54°29′,5 N. Lat	19—0	3°12—1°71	21·37—16·62	÷
10°21′ E. Long.				
1904 II 9				
DO 2				
54°56′,5 N. Lat.	32—0	3°44—1°84	21·85—17·57	÷
10°06′ E. Long.				
1904 II 10				
DO 3				
54°36′ N. Lat.	30—0	4°24—1°64	25·44—12·03	rr
11°02′ E. Long.	0	1°64	12·03	÷
1904 II 10				
DO 4				
54°10′ N. Lat.	32—0	3°32—1°59	20·44—14·15	÷
11°16′ E. Long.				
1904 II 12				
DO 5				
54°28′ N. Lat.	24—5	2°91—1°82	18·98—8·31	rr
12°15′ E Long.	5—0	1°82—1°89	8·31—8·33	÷
1904 II 11	0	1°89	8·33	÷

Then absent at all more easterly stations.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
III. May 1904				
1. North Sea. Germany				
DN Heligoland	0	—	—	+
DN 8				
58°20′ N. Lat.	350—150	5°21—[5°55][1])	35·12—[34·85]	rr
5°43′ E. Long.	150—70	[5°55]—[5°74]	[34·85]-[34·76]	rr
1904 V 4	70—25	[5°74]—[5°79]	[34·76]-[34·40]	rr
DN 9				
57°52′ N. Lat	430—150	5°50—3°96	35·03—34·46	rr
7°20′ E. Long.	70—25	[3°93]—[3°56]	[34·14]-[33·57]	rr
1904 V 5	0	5°79	29·56	r
DN 10				
57°32′ N. Lat.	230—0	[5°13]—5°49	[35·03]—31·32	r
7°36′ E Long.	230—150	[5°13]—5°87	[35·03]—35·03	rr
1904 V 5	150—25	5°87—[5°53]	35·03—[34·72]	rr
	25—5	[5°53]—5°34	[34·72]—31·47	rr
DN 12				
57°00′ N. Lat.	5—0	5°98—6°09	34·47—33·86	rr
8°03′ E. Long.				
1904 V 6				
DN 15				
55°02′ N. Lat.	27—0	6°54—6°99	33·87—33·44	r
7°30′ E. Long.	0	6°99	33·44	r
1904 V 7				
2. North Sea. Scotland				
Sc 8				
61°25′ N. Lat.	355—303	[6°09]—[5°98]	[35·19]-[35·12]	rr
3°00′ E Long.				
1904 V 2				
3. Skager Rak. Sweden				
S 0				
57°41′ N. Lat.	98—40	[5°40]—5°95	[34·85]—33·30	+
11°24′ E Long.				
1904 V 10				
S 8				
58°10′ N. Lat.	630—0	5°25—7°1	35·17—29·29	r [dead]
9°18′ E. Long.				
1904 V 17				
S 9				
58°21′ N. Lat.	230—0	[5°07]—6°8	[34·99]—28·44	r [dead]
8°56′ E. Long.				
1904 V 12				
S 13				
58°36′ N. Lat.	240—0	[5°29]—7°4	[34·97]—26·35	r [dead]
9°20′ E. Long.				
1904 V 12				

Station	Depths in Metcrs	Temperature in C°	Salinity ‰	Frequency
IV. August 1904				
1. North Sea. Germany				
DN Heligoland	0	—	—	cc
DN Elbe	0	—	—	cc
2. Kattegat. Denmark				
Da 12				
57°24′,8 N. Lat.	40—0	9°0—18°2	33·33—23·71	rr
10°48′,0 E.Long.				
1904 VIII 1				
V. November 1904				
1. North Sea. Belgium				
B 1				
51°23′,5 N. Lat.	18—0	[9°55]—10°3	[33·22]—33·04	r
2°58′ E. Long.	18[2])	[9°55]	[33·22]	r
1904 XI 14	0	10°3	33·04	+
B 2				
51°32′ N. Lat.	30—0	10°90—12°00	33·93—34·02	rr
2°41′ E. Long.	30[2])	10°90	33·93	rr
1904 XI 14	0	12°00	34·02	÷
B 3				
51°38′ N. Lat.	30—0	11°42—12°9	34·92—34·97	÷
2°29′ E. Long.	30[2])	11°42	34·92	÷
1904 XI 14	0	12°9	34·97	rr
B 9				
51°23′,5 N. Lat.	32—0	[10°81]—15°2	[34·13]—33 91	÷
2°28′ E. Long.	32[2])	[10°81]	[34·13]	r
1904 XI 14	0	15°2	33·91	rr
2. North Sea. Germany				
DN 1				
54°41′ N. Lat.	38—0	11°38—11°59	34·34—34·38	c
6°12′ E. Long.	0	11°59	34·38	+
1904 XI 13				
DN 2				
55°22′ N. Lat.	40—0	9°99—10°19	34·70—34·73	r
4°18′ E. Long.	40—30	9°99—[9°99]	34·70—[34·69]	÷
1904 XI 14	30—10	[9°99]—[9°99]	[34 69]-[34 69]	r
	10—0	[9°99]—10°19	[34·69]—34·73	+
DN 5				
57°24′ N Lat.	63—0	8°75—9°01	34·96—34·96	rr
3°41′ E. Long.	0	9°01	34·96	÷
1904 XI 15				

[1]) The figures in brackets are taken from the nearest depth where Tp. and Sal. have been observed; and this has been the case for the whole remaining part of the tables. [2]) horizontal.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
DN 6				
57°55′ N. Lat.	98—10	7°53—8°90	35·13—34·38	r
4°45′ E. Long.	10—0	8°90—9°27	34·38—34·13	r
1904 XI 16	0	9°27	34·13	+
DN 7				
58°10′ N. Lat.	285—75	[5°53]—7°70	[35·13]—34·95	÷
5°12′ E. Long.	75—15	7°70—9°93	34·95—33·45	+
1904 XI 16	15—0	9°93—9°19	33·45—32·66	r
	284—0	5°53—9°19	35·13—32·66	c
DN 8				
58°22′ N. Lat.	335—0	[5°61]—8°29	[35·12]—31·72	+
5°31′ E. Long.	10—0	8°28—8°29	31·51—31·72	r
1904 XI 16				
DN 10				
57°32′ N Lat.	228—75	7°54—8°04	35·23—35·02	÷
7°36′ E. Long.	75—10	8°04—8°45	35·02—33·33	+
1904 XI 22	10—0	8°45—8°09	33·33—33·68	r
DN 11				
57°17′ N. Lat.	57—0	[8°61]—7°99	[34·76]—33·74	r
7°47′ E. Long.				
1904 XI 21				
DN 12				
57°00′ N. Lat.	29—0	9°71—9°54	34·60—34·66	r
8°03′ E. Long.				
1904 XI 21				
DN 13	0	—	—	c
DN 14				
56°13′ N. Lat.	30—0	9°08—9°01	33·80—33·80	cc
7°21′ E. Long.				
1904 XI 23				
DN 15				
55°02′ N. Lat.	24—0	9°49—9°41	33·91—33·95	cc
7°30′ E. Long.				
1904 XI 23				

3. Skager Rak. Sweden

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S 0				
57°41′ N. Lat.	98—0	[10°44]—8°5	[34·47]—29·09	c
11°24′ E. Long.	40—0	10°25—8°5	33·60—29·09	c
1904 XI 9	0	8°5	29·09	cc
S 1				
58°03′ N. Lat.	125—0	9°34—8°9	35·10—33·24	r
10°48′ E. Long.	60—0	9°75—8°9	34·97—33·24	r
1904 XI 10	0	8°9	33·24	÷
S 2				
57°53′ N. Lat.	125—0	9°62—9°0	34·97—33·84	cc
10°42′ E. Long.	0	9°0	33·84	cc
1904 XI 10				
S 3				
58°12′ N. Lat.	75—0	7°52—9°0	35·01—32·74	c
10°29′ E. Long.	0	9°0	32·74	÷
1904 XI 10				
S 4				
58°13′ N. Lat.	125—50	9°80—10°03	34·92 34·72	c
11°00′ E. Long.	50—0	10°03—8°4	34·72—32·72	cc
1904 XI 10	0	8°4	32·72	cc
S 5				
57°42′ N. Lat.	65—0	[9°59]—9°1	[34·61]—33·98	cc
9°51′ E. Long.				
1904 XI 11				
S 6				
57°56′ N. Lat.	90—0	[9°91]—9°8	[34·76]—34·74	r
9°40′ E. Long				
1904 XI 11				
S 8				
58°10′ N. Lat.	150—0	7°04—8°9	35·19—32·57	c
9°18′ E. Long.	0	8°9	32·57	cc
1904 XI 11				
S 9				
58°15′ N. Lat.	300—150	6°22—7°26	35·12—35·12	+
9°05′ E. Long.	150—0	7°26—8°9	35·12—32·63	+
1904 XI 11				
S 10				
58°47′ N. Lat.	125—65	8°00—[9°26]	35·12—[35·08]	c
10°11′ E. Long.	65—0	[9°26]—8°1	[35·08]—31·94	c
1904 XI 12	0	8°1	31·94	+
S 13				
58°36′ N. Lat.	230—100	[7°18]—10°32	[35°16]—34°83	c
9°20′ E. Long.	100—0	10°32—7°8	34·83—30·25	cc
1904 XI 12				
S 14				
58°49′,6 N. Lat.	250—75	[5°67]—11°10	[34·76]—34·23	cc
11°05′,7 E. Long.	75—0	11°10—8°9	34·23—31·78	cc
1904 XI 12	0	8°9	31·78	cc
S 15				
58°15′,8 N. Lat.	48—0	[10°91]—7°3	[33·53]—27·21	cc
11°26′,8 E. Long.				
1904 XI 9				
S 16				
58°19′,3 N. Lat.	115—65	5°26—[8°29]	34·45—[34·14]	r
11°32′,6 E. Long.	65—0	[8°29]—7°5	[34·14]—28·96	c
1904 XI 14				
S 17				
58°23′ N. Lat.	38—0	[11°69]—6°1	[33·57]—26·24	r
11°34′ E. Long.				
1904 XI 14				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
4. Skager Rak, Kattegat. Denmark				
Da 4				
57°57′,7 N. Lat.	180—0	7°6—10°2	35·19—32·97	r
10°49′,6 E Long.	50—0	10°8—10°2	35·05—32·97	rr
1904 XI 1				
Da 7				
57°52′,0 N. Lat.	80—0	[9°0]—9°2	[34·85]—25·77	cc
11°18′,0 E. Long.	50—0	11°3—9°2	33·82—25·77	c
1904 XI 1	10—0	11°1—9°2	31·09—25·77	r
Da 9				
57°41′,0 N. Lat.	89—0	9°7—9°0	34·87—27·90	c
11°23′,0 E. Long.	50—0	11°5—9°0	33·96—27·90	c
1904 XI 2	40—0	11°3—9°0	31·35—27·90	r
Da 12				
57°24′,8 N. Lat.	38—0	11°8—9°2	33·89—25·30	c
10°48′,0 E. Long.	10—0	9°6—9°2	25·97—25·30	rr
1904 XI 2				
Da 15				
57°17′,9 N. Lat.	75—55	9°6—[10°2]	34·60—[34·40]	c
11°27′,4 E. Long.	30—15	11°0—11°4	33·86—31·62	c
1904 XI 1	10—0	10°6—9°1	28·03—21·78	rr
Da 18				
56°47′,3 N. Lat.	30—17·5	11°6—12°1	33·78—32·18	rr
11°47′,0 E. Long.	35—0	11°3—9°4	33·91—20·50	rr
1904 XI 1	15—0	10°0—9°4	24·00—20·50	÷

VI. February 1905

1. North Sea. Germany

DN 1				
54°41′ N. Lat.	35—0	[4°24]—3°99	[34·32]—34·09	+
6°12′ E. Long.	0	3°99	34·09	c
1905 II 13				
DN 2				
55°22′ N. Lat.	44—0	5°07—5°01	34·95—34·93	rr
4°18′ E. Long.	0	5°01	34·93	r
1905 II 13				
DN 3				
56°02′ N. Lat.	70—0	5°57—5°69	35·03—35·02	rr
3°16′ E. Long.	0	5°69	35·02	rr
1905 II 14				
DN 6				
57°55′ N. Lat.	0	6°41	35·30	rr
4°45′ E. Long.				
1905 II 15				
DN 7				
58°10′ N. Lat.	100—0	6°98—4°59	35·14—33·77	r
5°12′ E. Long.	50—0	6°58—4°59	34·86—33·77	rr
1905 II 15	0	4°59	33·77	r
DN 8				
58°22′ N. Lat.	325—75	6°58—5°98	35·17—34·63	r
5°31′ E. Long.	70—0	[5°98]—5°34	[34·63]—33 66	÷
1905 II 15	325—0	6°58—5°34	35·17—33·66	+
	0	5°34	33·66	r
DN 10				
57°32′ N. Lat.	150—0	6°50—4°79	35·25—34·44	r
7°36′ E Long.	60—5	[5°87]—4°79	[34·85]—34·44	rr
1905 II 20	25—0	[4°79]—4°79	[34·34]—34·44	rr
	0	4°79	34·44	÷
DN 14				
56°21′ N. Lat.	31—0	3°98—3°19	34·23—33·59	+
7°22′ E. Long.	15—0	3°80—3°19	34·14—33·59	c
1905 II 21	0	3°19	33·59	c
DN 15				
55°02′ N. Lat.	21—0	[3°18]—3°19	[33·21]—33·21	cc
7°30′ E. Long.	0	3°19	33·21	cc
1905 II 21				

2. Skager Rak, Kattegat, Belt Sea. Denmark

Da 4				
57°57′,7 N. Lat.	180—0	5°8—5°55	34·96—34·65	+
10°49′,6 E Long.	100—0	5°95—5°55	34·93—34·65	r
1905 II 1	20—0	5°7—5°55	34·65—34·65	rr
Da 12				
57°24′,8 N. Lat.	45—0	[3°45]—3°1	[34·09]—33·71	+
10°48′,0 E. Long.	20—0	3°25—3°1	33·71—33·71	+
1905 II 2				
Da 23				
55°46′,7 N. Lat.	50—20	[2°1]—1°9	[24·14]—23·26	÷
10°48′,8 E. Long.	50—0	[2°1]—1°7	[24·14]—22·63	÷
1905 II 1	20—0	1°9—1°7	23 26—22·63	rr
Da 26				
55°20′,4 N. Lat.	60—20	1°62—1°71	22·70—21·06	rr
11°02′,3 E. Long.	60—0	1°62—1°5	22 70—21·13	rr
1905 II 1	20—0	1°71—1°5	21 06—21·13	÷
Da 29				
55°01′,5 N. Lat.	30—15	1°42—1°39	21·47—21·22	rr
11°02′,2 E. Long.	30—0	1°42—1°10	21·47—19·87	÷
1905 II 3	15—0	1°39—1°10	21·22—19·87	÷

3. Baltic. Germany
(After H. Driver 1907)

DO 12				
54°54′ N. Lat.	105—60	5°18—[3°16]	11·20—[7·56]	rr [180]
19°15′ E. Long.	60—0	[3°16]—2°79	[7·56]—7·45	rr [3]
1905 II 5				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
VII. May 1905				
1. North Sea. Germany				
DN 4				
56°41′ N. Lat.	5—0	7°37—7°44	34·98—34·97	×
2°15′ E. Long.				
1905 V 12				
DN 5				
57°22′ N. Lat.	60—30	5°62—5°65	35·12—35·03	×
3°35′ E. Long.				
1905 V 12				
DN 6				
57°55′ N. Lat.	102—5	5°99—7°69	35·21—34·23	×
4°45′ E. Long.				
1905 V 13				
DN 7				
58°10′ N. Lat.	295—100	5°61—5°86	35·12—35·04	×
5°12′,5 E. Long.	100—5	5°86—5°84	35·04—33·26	×
1905 V 13				
DN 8				
58°23′ N. Lat.	335—150	5°67—5°30	35·12—34·76	×
5°56′ E. Long.	150—50	5°30—4°88	34·76—34·42	×
1905 V 14	50—5	4°88—5°79	34·42—33·26	×
DN 9				
57°52′ N. Lat.	445—150	[5°61]—5°48	[35·03]—34·89	×
7°20′ E. Long.	150—40	5°48—4°90	34·89—34·09	×
1905 V 16	40—25	4°90—[5°59]	34·09—[33·43]	×
DN 10				
57°32′ N. Lat.	215—75	5°79—6°10	35·12—35·03	×
7°36′ E. Long.				
1905 V 16				
DN 11				
57°17′ N. Lat.	55—30	[5°59]—5°70	[35·07]—35·07	×
7°47′ E. Long.				
1905 V 16				
DN 14				
56°13′ N. Lat.	30—5	5°87—9°10	34·23—33·60	×
7°21′ E. Long.	5—0	9°10—10°04	33·60—31·53	×
1905 V 17				
DN 15				
55°02′ N. Lat.	20—5	7°21—10°02	33·30—31·53	×
7°30′ E. Long.	5—0	10°02—10°04	31·53—31·53	×
1905 V 18				
2. North Sea. Scotland				
Sc 8				
61°30′ N. Lat.	384—100	6°34—6°44	35·19—34·79	+
3°03′ E. Long.				
1905 V 26				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
3. Norwegian Sea. Norway				
N 2 C				
61°26′ N. Lat.	250—100	[7°20]—6°61	[35·23]—35·03	rr
2°40′ E. Long	60—0	[6°0]—7°18	[34·75]—31·95	÷
1905 V 16				
N 3				
61°44′ N. Lat.	200—75	7°09—7°61	35·25—35·23	+
1°39′ E Long.	50—0	7°78—8°2	35·25—35·22	÷
1905 V 16				
N 37				
63°09′ N Lat.	650—0	[1°27]—8°20	[34·95]—35·23	rr
2°18′ E. Long.	400—150	6°04—[7°38]	35·16—[35·23]	r
1905 V 25	70—0	[7°62]—8°20	[35·36]—35·23	÷
N 40				
62°26′ N. Lat.	170—90	[6°97]—[6°12]	[35·17]-[34·80]	r
3°42′ E. Long.	80—0	[6°10]—7°5	[34·80]—32·56	÷
1905 V 25				
4. Skager Rak, Kattegat. Denmark				
Da 4				
57°57′,7 N. Lat.	140—100	[5°3]—5°4	[34·99]—34·99	rr
10°49′,6 E. Long.	75 40	5°9—5°4	34·99—34·88	rr
1905 V 1	30—12	5°1—[5°2]	34·76—[33·08]	÷
	10—0	5°2—5°9	33·08—30·77	÷
	0	5°9	30·77	÷
Da 7				
57°52′,0 N. Lat.	75—30	5°35—5°55	34·36—33·69	rr
11°18′,0 E. Long.	20—0	4°95—5°9	31·27—24·56	÷
1905 V 1				
Da 12				
57°24′,8 N. Lat.	40—0	4°65—5°8	34·51—21·62	rr
10°48′,0 E. Long	35—15	[4°65]—4°5	[34·51]—32·81	rr
1905 V 2	5—0	5°75—5°8	21·62—21·62	÷
5. Belt Sea. Germany (After H. Driver, 1907)				
DO 2				
54°56′,5 N. Lat.	33—0	2°67—5°34	20·61—15·82	r [1000]
10°06′ E. Long.				
1905 V 4				
DO 3				
54°36′ N. Lat.	34—25	[3°67]—3°86	[20·05]—18·62	rr [350]
11°02′ E. Long.				
1905 V 2				
DO 4				
54°10′ N. Lat.	23—0	[4°06]—6°31	[16·89]—14·00	×
11°16′ E. Long.				
1905 V 2				
DO 5				
54°28′ N. Lat.	27—15	3°98—4°18	16·78—15·52	rr
12°15′ E. Long.				
1905 V 2				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
VIII. August 1905				
1. North Sea. Germany				
DN 8				
58°22′ N. Lat.	330—150	[6°20]—6°23	[35·27]—35·12	×
5°31′ E. Long.				
1905 VIII 15				
DN 10				
57°32′ N. Lat.	230—40	6°47—7°12	35·29—34·97	×
7°36′ E. Long.				
1905 VIII 17				
DN 12				
57°11′ N. Lat.	29—0	[10°95]—16°11	[34·33]—32·74	×
7°52′ E. Long.				
1905 VIII 18				
DN 15				
55°03′ N. Lat.	26—0	[15°82]—15°99	[32·81]—32·82	×
7°30′ E. Long.				
1905 VIII 20				
(After F. Kraefft 1907 and C. Brockmann 1906)				
Station 1				
Umweit Hohen-	14—0	15°48 (10 m)	28·31 (10 m)	×
weg Leuchtfeuer	0	—	—	×
(Wesermündung)				
1905 IX 1				
Station 9				
55°07′ N. Lat.	10—0	13°34 (0 m)	34·70 (0 m)	× [800]
1°43′ E. Long.				
1905 IX 15				
Heligoland				
1905 VII	—	—	—	×[1]
Weser bei Bremerhafen				
VIII 21—IX 28	—	—	—	×
2. Skager Rak. Sweden				
S Skag 7				
58°26′ N. Lat.	630—0	[5°45]—15°28	[34·97]—29·81	rr
9°44′ E. Long.				
1905 VIII 4				
S Skag 9				
58°02′ N. Lat.	50—0	8°83—15°50	35·07—30·28	rr
8°56′ E. Long.				
1905 VIII 4				
3. Skager Rak, Kattegat. Denmark				
Da 7				
57°52′,0 N. Lat.	90—50	[7°7]—12°1	[34·83]—34·47	rr
11°18′,0 E. Long.	30—0	14°3—16°1	32 66—30·12	÷
1905 VIII 1				
Da 9				
57°41′,0 N. Lat.	90—0	7°2—16°1	34·22—29·97	rr
11°23′,0 E. Long.	75—50	7°2—11°1	34·22—33·35	rr
1905 VIII 1				
Da 12				
57°24′,8 N. Lat.	39—20	9°7—13°9	33·48—29·33	rr
10°48′,0 E. Long.	15—0	16°85—16°6	29·33—29·29	÷
1905 VIII 1				
Da 15				
57°17′,9 N. Lat.	66—40	6°18—7°48	34·11—33·44	rr
11°24′,4 E. Long.	20—0	16°10—17°5	30·68—23·95	÷
1905 VIII 2				
Da 18				
56°47′,3 N. Lat.	50—40	15°50—15°75	33·53—33·44	rr
11°47′,0 E. Long.	40—0	15°75—17°8	33·44—20·59	÷
1905 VIII 1				
IX. November 1905				
1. North Sea. Belgium.				
B 1				
51°23′ N. Lat.	15—0	[9°12]—9°1	[32·83]—32·79	c
2°59′ E. Long.	15[2]	[9°12]	[32·83]	c
1905 XI 9	0	9°1	32·79	c
B 2				
51°31′ N. Lat.	36—0	10°9—10°9	34·74—34·72	+
2°43′ E. Long.	36[2]	10°9	34·74	+
1905 XI 9	0	10°9	34·72	+
B 3				
51°37′ N. Lat.	38—0	11°12—11°15	34·83—34·85	r
2°30′ E. Long.	38[2]	11°12	34·83	r
1905 XI 9	0	11°15	34·85	r
B 4				
51°43′,5 N. Lat.	38—0	—	—	rr
2°18′ E. Long.	38[2]	—	—	r
1905 XI	0	—	—	⊥
B 5				
51°48′ N. Lat.	43—0	[11°50]—11°45	[35·10]—35·10	+
2°18′ E. Long.	43[2]	[11°50]	[35·10]	r
1905 XI 10	0	11°45	35·10	+
B 6				
51°53′,5 N. Lat.	35—0	—	—	rr
2°04′ E. Long.	35[2]	—	—	rr
1905 XI	0	—	—	rr
B 9				
51°23′ N. Lat.	31—0	[11°23]—11°17	[34·92]—34·94	c
2°27′ E. Long.	31[2]	[11°23]	[34·92]	+
1905 XI 9	0	11°17	34·94	+
B 9a				
51°40′ N. Lat.	21—0	10°20—10°05	35·01—34·99	÷
1°41′ E. Long.	21[2]	10°20	35·01	÷
1905 XI 10	0	10°05	34·99	rr
B 17	27—0	—	—	rr
	27[2]	—	—	÷
	0	—	—	÷

[1]) «häufig». [2]) horizontal.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
2. North Sea. Holland				
H 2				
53°44′ N. Lat.	0	—	—	rr [1])
3°48′ E. Long.				
1905 XI				
H 9				
52°15′ N. Lat.	0	11°0	34·69	cc
3°28′ E. Long.				
1905 XI 5				
3. North Sea. Germany				
DN 1				
54°41′ N. Lat.	40—0	[9°83]—9°39	[34·65]—34·65	×
6°12′ E. Long.	0	9°39	34·65	÷
1905 XI 16				
DN 2				
55°22′ N. Lat.	42—0	[9°10]—8°84	[34·88]—34·88	×
4°18′ E. Long.	0	8°84	34·88	×
1905 XI 17				
DN 6				
57°55′ N. Lat.	98—75	7°32—7°77	35·17—35·16	×
4°45′ E. Long.	75—0	7°77—7°74	35·16—34·18	×
1905 XI 18	5—0	8°12—7°74	34·18—34·18	×
	0	7°74	34·18	×
DN 7				
58°10′ N. Lat.	280—150	6°38—9°06	35·16—35·26	×
5°12′ E. Long.	150—75	9°06—8°51	35·26—33·91	×
1905 XI 19	75—30	8°51—8°21	33 91—33·39	×
	30—10	8°21—7°80	33·39—31·79	×
	10—0	7°80—6°44	31·79—30·90	×
	0	6°44	30·90	×
DN 8				
58°22′ N. Lat.	330—230	6°15—[6°28]	35·16—[35·16]	×
5°31′ E. Long.	230—130	[6°28]—[7°34]	[35·16]-[35·07]	×
1905 XI 19	130—10	[7°34]—7°80	[35·07]—31·44	×
	10—0	7°80—6°09	31·44—29·92	×
	0	6°09	29·92	×
DN 10				
57°32′ N. Lat.	190—100	7°08—8°14	35·25—34·79	×
7°36′ E. Long.	100—20	8°14—8°31	34·79—34 09	×
1905 XI 21	20—5	8°31—6°38	34·09—30·90	×
	5—0	6°38—6°24	30·90—30·90	×
	0	6°24	30·90	×
DN 11				
57°17′ N. Lat.	50—5	6°46—7°08	35·16—34·18	×
7°47′ E. Long.	5—0	7°08—7°69	34·18—34·27	×
1905 XI 22	0	7°69	34·27	×
DN 12				
57°00′ N. Lat.	32—0	[6°21]—6°69	[34·88]—34·79	×
8°03′ E. Long.	0	6°69	34·79	×
1905 XI 22				
DN 13				
56°45′ N. Lat.	47—0	[8°58]—8°69	[34·79]—34·70	×
6°06′ E. Long.				
1905 XI 22				
DN 15				
55°02′ N. Lat.	29—0	[8°04]—8°14	[33·49]—33·56	×
7°30′ E. Long.	0	8°14	33·56	×
1905 XI 23				
4. Skager Rak. Sweden				
S Skag 0				
57°41′ N. Lat.	67—15	[7°46]—8°70	[35·14]—33·28	cc
11°24′ E. Long.	15—0	8°70—5°3	33·28—19·22	c
1905 XI 14				
S Skag 1				
58°03′ N. Lat.	180—0	[6°58]—6°90	[35·16]—30·01	cc
10°48′ E. Long.	60—0	9°31—6°90	34·40—30·01	cc
1905 XI 17	0	6°90	30·01	cc
S Skag 2				
57°53′ N. Lat.	148—0	[6°04]—5°6	[35·19]—19·69	c
10°42′ E. Long.	40—0	8°19—5°6	35·01—19·69	+
1905 XI 14	0	5°6	19·69	+
S Skag 3				
58°12′ N. Lat.	210—60	[5°95]—9°25	[35·12]—34·65	cc
10°29 E. Long.	60—0	9°25—4°95	34·65—26·27	+
1905 XI 17	0	4°95	26·27	cc
S Skag 4				
58°13′ N. Lat.	124—60	[6°24]—8°31	[35·16]—34·99	cc
11°00′ E. Long.	60—0	8°31—5°46	34·99—27·47	c
1905 XI 17	0	5°46	27·47	+
S Skag 5				
57°42′ N. Lat.	0	7°5	29·61	+
9°51′ E. Long.				
1905 XI 15				
S Skag 6				
57°56′ N. Lat.	130—0	6°13—5°70	35·14—[28·12]	cc
9°40′ E. Long.	40—0	8°42—5°70	34·76—[28·12]	cc
1905 XI 18	0	5°70	[28·12]	c
S Skag 7				
58°26′ N. Lat.	300—100	6°24—7°68	35·21—35·14	cc
9°44′ E. Long.	100—0	7°68—3°97	35·14—23·89	cc
1905 XI 18	0	3°97	23·89	+
S Skag 8				
58°10′ N. Lat.	570—300	[5°65]—6°38	[35·17]—35·17	+
9°18′ E. Long.	0	4°69	23·62	c
1905 XI 18				
S Skag 9				
58°21′ N. Lat.	225—60	[5°83]—8°44	[35·12]—34·94	c
8°56′ E. Long.	60—0	8°44—4°14	34·94—22·83	cc
1905 XI 18	0	4°14	22·83	+

[1]) The record is perhaps wrong, as the same net as that used at Stat. H 9 (letter from P. J. van Breemen).

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S Skag 10				
58°48′ N. Lat.	150—50	[6°25]—7°59	[35·19]—34·99	c
10°23′ E. Long.	50—0	7°59—4°15	34·99—25·21	+
1905 XI 19	0	4°15	25·21	+
S Skag 13				
58°32′,5 N. Lat.	260—60	[5°78]—5°59	[35·16]—35·07	c
9°09′ E. Long.	60—0	5°59—3°65	35·07—23·64	+
1905 XI 19	0	3°65	23·64	+
S Skag 14				
58°49′,6 N. Lat.	240—75	[6°72]—7°70	[35·16]—34·99	cc
11°05′,7 E. Long.	75—0	7°70—4°70	34·99—28·44	c
1905 XI 19	0	4°70	28·44	+
S Skag 15				
58°15′,8 N Lat.	52—0	[7°63]—8°61	[34·96]—33·51	c
11°26′,8 E. Long.	0	8°61	33·51	cc
1905 XI 17				
S Skag 16				
58°19′,3 N. Lat.	115—40	[4°71]—8°53	[34·07]—34·23	+
11°32′,6 E. Long.	40—0	8°53—8°94	34·23—33·37	+
1905 XI 16	0	8°94	33·37	c
S Skag 17				
58°23′ N. Lat.	40—0	[8°88]—9°02	[34·22]—33·69	+
11°34′,7 E. Long.	0	9°02	33·69	c
1905 XI 16				

5. Skager Rak and Kattegat. Denmark

Da 4				
57°57′,7 N. Lat.	174—0	7°85—8°7	33·12—32·27	c
10°49′,6 E. Long.				
1905 XI 1				
Da 7				
57°52′,0 N. Lat.	85—0	[8°15]—7°15	[34·90]—21·42	c
11°18′,0 E. Long.				
1905 XI 1				
Da 9				
57°4′,0 N. Lat.	95—0	7°9—7°4	34·97—22·29	c
11°23′,0 E. Long.	75—20	8°7—8°5	34·51—29·79	c
1905 XI 2	15—0	7°5—7°4	25·23—22·29	r
Da 12				
57°24′,8 N. Lat.	34—0	9°15—7°3	34·72—23·22	r
10°48′,0 E. Long	10—0	9°9—7°3	31·49—23·22	÷
1905 XI 2	0	7°3	23·22	rr
Da 15				
57°17′,9 N. Lat.	58—0	9°44—[7°45]	34·72—24·52	rr
11°27′,4 E. Long.	25—0	[10°34]—[7°45]	[34·36]—24·52	rr
1905 XI 1				
Da 18				
56°47′,3 N. Lat.	40—0	10°40—7°5	33·89—21·60	rr
11°47′,0 E. Long.	40—15	10°40—10°90	33·89—31·08	+
1905 XI 1	10—0	7°52—7°5	21·74—21·60	÷

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency

6. Baltic. Germany

DO 8				
54°54′ N. Lat.	45—40	[9°65]—[8°72]	[8·71]—[8·10]	×
13°12′ E. Long.				
1905 XI 3				

X. February 1906

1. North Sea. Belgium

B 1				
51°23′ N. Lat.	16—0	4°9—4°8	32·84—32·74	rr
2°58′ E. Long.	0	4°8	32·74	rr
1906 II 5				
B 2				
51°32′ N. Lat.	0	6°5	35·10	rr
2°40′ E. Long.				
1906 II 5				
B 11				
50°58′,5 N. Lat.	56—0	7°25—7°3	35·19—35·19	rr
1°27′ E. Long.				
1906 II 6				

2. North Sea. Holland

H 2				
53°44′ N. Lat.	0	—	—	rr
3°28′ E Long.				
1906 II				

3. North Sea. Germany

DN 6				
57°54′,5 N. Lat.	95—75	[6°52]—6°54	[35·14]—35·14	÷
4°53′ E. Long.	75—0	6°54—5°49	35·14—34·61	×
1906 II 18				
DN 7				
58°10′ N. Lat.	300—0	6°23—4°54	35·14—33·55	×
5°12′ E. Long.				
1906 II 17				
DN 8				
58°22′ N. Lat.	0	4°41	33·64	×
5°31′ E. Long.				
1906 II 17				
DN 9				
57°52′ N. Lat.	440—350	6°35—6°49	35·23—35·14	×
7°20′ E. Long.	350—100	6°49—6°38	35·14—34·69	×
1906 II 21	100—0	6°38—2°79	34·69—32·05	×
DN 10				
57°32′ N Lat.	210—75	[6°53]—5°04	[35·16]—34·79	×
7°36′ E. Long.	15—0	5°60—4°54	34·63—34·07	×
1906 II 21				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
DN 12				
57°00′ N. Lat.	33—0	3°52—3°49	33·75—33·75	×
8°03′ E. Long.				
1906 II 22				
DN 14				
56°13′ N. Lat.	31—0	[3°72]—3°29	[33·78]—33·39	×
7°21′ E. Long.				
1906 II 23				
DN 15				
55°02′ N. Lat.	24—0	3°20—2°89	32·81—32·50	×
7°30′ E. Long.				
1906 II 24				
4. Skager Rak. Sweden				
S Skag 1				
58°03′ N. Lat.	135—50	[4°51]—4°37	[34·81]—34·67	c
10°48′ E. Long.	50—0	4°37—2°4	34·67—29·92	c
1906 III 10				
S Skag 4				
58°13′ N. Lat.	125—0	[4°33]—2°5	[34·72]—30·68	c
11°00′ E. Long.	0	2°5	30·68	÷
1906 III 10				
S Skag 7				
58°26′ N. Lat.	440—0	[5°95]—3°2	[35·14]—32·48	+
9°44′ E. Long.	0	3°2	32·48	÷
1906 III 7				
S Skag 8				
58°10′ N. Lat.	100—0	7°04—3°5	35·12—33·21	+
9°18′ E. Long.				
1906 III 13				
S Skag 10				
58°48′ N. Lat.	145—0	[4°11]—2°8	[34·69]—31·82	+
10°23′ E. Long.	0	2°8	31·82	÷
1906 III 11				
S Skag 0				
57°41′ N. Lat	90—0	[4°33]—2°6	[34·52]—32·00	c
11°24′ E. Long	0	2°6	32·00	÷
1906 III 14				
5. Skager Rak, Kattegat. Denmark				
Da 4				
57°57′,7 N. Lat.	172—0	5°5—4°6	34·92—33·48	rr
10°49′,6 E. Long.	20—0	4°75—4°6	33·60—33·48	÷
1906 II 1				
Da 7				
57°52′,0 N. Lat.	80—0	4°6—3°4	33·40—32·38	r
11°18′,0 E. Long.				
1906 II 1				
Da 9				
57°41′,0 N. Lat.	96—0	4°4—3°4	33·77—32·30	+
11°23′,0 E. Long.	50—0	3°9—3°4	33·08—32·30	+
1906 II 2	0	3°4	32·30	rr
Da 12				
57°24′,8 N. Lat.	33—0	3°9—3°1	32·94—32·00	r
10°48′,0 E. Long.	0	3°1	32·00	rr
1906 II 2				
Da 15				
57°17′,9 N. Lat.	72—50	5°6—4°1	34·20—33·24	r
11°27′,4 E. Long.	70—0	[5°6]—2°9	[34·20]—29·11	r
1906 II 1	40—0	3°6—2°9	32·70—29·11	÷
Da 18				
56°47′,3 N. Lat.	40—25	[5°9]—[5°4]	33·55—[32·95]	rr
11°47′,0 E. Long.	15—0	2°7—2°3	26·29—25·12	÷
1906 II 1				
XI. May 1906				
1. North Sea. Belgium				
B 1				
51°23′ N. Lat.	18—0	[7°75]—7°90	[30·34]—29·65	r
2°58′,5 E. Long.	0	7°90	29·65	rr
1906 V 30				
2. North Sea. Germany				
DN 8				
58°22′ N. Lat.	320—100	5°78—5°44	35·25—34·74	×
5°31′ E. Long.				
1906 V 15				
DN 9				
57°52′ N. Lat.	410—100	[5°58]—5°25	[35·16]—34·74	×
7°20′ E. Long.				
1906 V 17				
DN 15				
55°00′ N. Lat.	28—0	[6°58]—10°94	[33·04]—30·41	×
7°31′ E. Long.				
1906 V 19				
3. North Sea. Scotland				
Sc 7 a				
60°45′ N. Lat.	129—0	6°75—6°44	35·32—35·32	rr
2°30′ E Long.				
1906 IV 13				
4. Skager Rak. Sweden				
S Skag 8				
58°10′ N. Lat.	660—150	[5°54]—6°36	[35·17]—35·08	r
9°18′ E Long.	150—40	6°36—6°01	35·08—34·72	r
1906 V 18	40—10	6°01—6°02	34·72—31·80	÷
	10—0	6°02—8°74	31·80—26·13	÷
S Skag 10				
58°48′ N. Lat.	155—0	5°70—10°14	35·14—20·12	rr
10°23′ E. Long.				
1906 V 21				
S Skag 16				
58°19′,3 N. Lat.	116—60	6°96—5°46	34·65—34·20	rr
11°32′,6 E. Long.				
1906 V 12				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
5. Baltic. Sweden				
S 5				
55°26′ N. Lat.	28—0	[4°53]—9°11	[7·72]—7·39	rr
14°46′ E. Long.				
1906 V 27				
XII. August 1906				
1. North Sea. Germany				
DN 12				
57°00′ N. Lat.	27—0	[15°06]—14°79	[32·79]—32·89	×
8°03′ E. Long.				
1906 VIII 23				
DN 15				
55°02′ N. Lat.	29—0	[15°37]—15°69	[32·70]—31·82	×
7°30′ E. Long.	0	15°69	31·82	×
1906 VIII 23				
XIII. November 1906				
1. North Sea. Belgium				
B 1				
51°28′,3 N. Lat.	15—0	[10°8]—10°71	[32·70]—32·59	+
2°58′ E. Long.	15 [1])	[10°8]	[32·70]	c
1906 XI 13	0	10°71	32·59	c
B 2				
51°32′,5 N. Lat.	40—0	[12°62]—12°6	[34·67]—34·67	c
2°40′,5 E. Long.	40 [1])	[12°62]	[34·67]	r
1906 XI 12	0	12°6	34·67	+
B 3				
51°37′,0 N. Lat.	31—0	[13°01]—13°00	[34·90]—34·88	rr
2°30′ E. Long.	31 [1])	[13°01]	[34·90]	÷
1906 XI 12	0	13°00	34·88	rr
B 9				
51°22′,8 N. Lat.	36—0	[12°78]—12°75	[34·76]—34·76	+
2°27′ E. Long.	36 [1])	[12°78]	[34·76]	r
1906 XI 13	0	12°75	34·76	+
B 10				
50°55′ N. Lat.	46—0	[13°13]—12°9	[34·78]—34·67	r
1°32′ E. Long.	46 [1])	[13°13]	[34·78]	÷
1906 XI 11	0	12°9	34·67	rr
2. North Sea. Holland				
H 2				
53°44′ N. Lat.	35—0	12°0—12°0	34·65—34·67	+
3°28′ E. Long.				
1906 XI 12				
H 3				
54°05′ N. Lat.	50—0	[9°2]—9°8	[34·63]—34·60	r
2°57′ E. Long.				
1906 XI 11				
H 9				
52°15′ N. Lat.	25—0	13°5—13°5	34·81—34·81	+
3°28′ E. Long.				
1906 XI 7				

[1]) horizontal.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
3. North Sea. Germany				
DN 1				
54°41′ N. Lat.	40—0	12°45—12°19	34·51—34·51	×
6°12′ E. Long.	0	12°19	34·51	÷
1906 XI 13				
DN 3				
56°02′ N. Lat.	70—0	[7°05]—9°39	[34·85]—34·67	×
3°16′ E. Long.	0	9°39	34·67	÷
1906 XI 14				
DN 6				
57°55′ N. Lat.	99—0	7°57—8°19	35·12—32·99	×
4°45′ E. Long.				
1906 XI 17				
DN 7				
58°10′ N. Lat.	285—75	[6°40]—9°17	[35·30]—35·03	×
5°12′,5 E. Long.	75—0	9°17—8°84	35·03—33·84	×
1906 XI 16				
DN 8				
58°22′ N. Lat.	330—150	[5°81]—6°57	[35·03]—35·03	×
5°31′ E. Long.	150—75	6°57—8°85	35·03—34·94	×
1906 XI 16	75—10	8°85—9°71	34·94—32·20	×
	10—0	9°71—9°29	32·20—32·21	×
	0	9°29	32·21	×
DN 9				
57°52′ N. Lat.	460—100	6°00—7°69	35·12—34·94	×
7°20′ E. Long.	100—20	7°69—7°86	34·94—28·48	×
1906 XI 21	20—0	7°86—7°79	28·48—28·30	×
	0	7°79	28·30	×
DN 10				
57°32′ N. Lat.	205—50	5°76—8°46	35·12—34·85	×
7°36′ E. Long.	50—20	8°46—9°84	34·85—34·23	×
1906 XI 21	20—0	9°84—8°99	34·23—32·99	×
	0	8°99	32·99	×
DN 11				
57°17′ N. Lat.	50—0	10°77—10°59	34·14—34·05	×
7°47′ E. Long.	0	10°59	34·05	×
1906 XI 21				
DN 12				
57°00′ N. Lat.	30—0	9°64—9°54	32·20—32·29	×
8°03′ E. Long.	0	9°54	32·29	×
1906 XI 22				
DN 14				
56°13′ N. Lat.	29—0	[10°74]—10°74	[33·64]—33·37	×
7°21′ E. Long.	0	10°74	33·37	×
1906 XI 22				
DN 15				
55°02′ N. Lat.	26—0	[10°81]—10°89	[33·64]—33·64	×
7°30′ E. Long.	0	10°89	33·64	×
1906 XI 23				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
4. Skager Rak. Sweden				
S Skag 0				
57°41′ N. Lat.	78—45	[6°92]—7°79	[35·14]—34·97	+
11°24′ E. Long.	40—0	10°07—9°00	34·45—29·65	cc
1906 XI 13	0	9°00	29·65	c
S Skag 1				
58°03′ N. Lat.	228—100	6°12—7°39	35·23—35·05	+
10°48′ E. Long.	75—20	10°49—10°93	34·34—32·45	c
1906 XI 13	15—0	8°87—8°28	28·57—27·41	c
	0	8°28	27·41	c
S Skag 2				
57°53′ N. Lat.	150—50	[6°58]—11°19	[35·16]—33·68	cc
10°42′ E. Long.	50—0	11°19—8°12	33·68—26·49	c
1906 XI 13	0	8°12	26·49	+
S Skag 3				
58°12′ N. Lat.	250—100	[6°36]—7°47	[35·23]—35·03	+
10°29′ E. Long.	60—0	11°54—8°29	34·07—26·91	c
1906 XI 13	0	8°29	26·91	c
S Skag 4				
58°13′ N. Lat.	100—40	[7°37]—9°73	[35·03]—34·63	c
11°00′ E. Long.	35—0	8°15—7°65	33·22—27·21	c
1906 XI 16				
S Skag 5				
57°42′ N. Lat.	70—0	7°01—7°09	34·96—30·21	cc
9°51′ E. Long.				
1906 XI 14				
S Skag 6				
57°56′ N. Lat.	0	8°15	28·13	r
9°40′ E. Long.				
1906 XI 14				
S Skag 7				
58°26′ N. Lat.	400—200	6°03—6°50	35·14—35·12	+
9°44′ E. Long.	250—76	[6°28]—[8°31]	[35·12]-[34·78]	c
1906 XI 15	75—0	8°31—7°96	34·78—26·60	c
S Skag 8				
58°10′ N. Lat.	525—100	[5°73]—6°99	[35·21]—35·21	c
9°18′ E. Long.	50—0	9°79—8°46	[34·54]—27·97	c
1906 XI 14				
S Skag 9				
58°21′ N. Lat.	250—40	6°00—8°74	35·19—34·69	c
8°56′ E. Long.	40—0	8°74—8°39	34·69—26·74	c
1906 XI 15				
S Skag 10				
58°48′ N. Lat.	140—75	[6°57]—9°36	[35·14]—33·65	+
10°23′ E. Long.	75—0	9°36—8°29	33·65—26·69	+
1906 XI 15				
S Skag 13				
58°36′ N. Lat.	200—40	6°28—8°82	35·17—34·60	c
9°20′ E. Long.	40—0	8°82—8°40	34·60—27·81	c
1906 XI 15				
S Skag 14				
58°49′,2 N. Lat.	230—75	[6°29]—7°77	[34·72]—34·81	c
11°05′,2 E. Long.	60—25	8°19—9°80	34·72—32·09	+
1906 XI 16	20—0	8°29—8°05	28·55—28·01	+
S Skag 16				
58°19′,3 N. Lat.	100—50	[7°69]—7°10	[34·83]—34·51	+
11°32′,6 E. Long.	50—0	7°10—6°79	34·51—24·11	c
1906 XI 18				
S Skag 17				
58°22′,7 N. Lat.	36—0	7°50—6°66	34·47—23·75	+
11°34′,7 E. Long.	0	6°66	23·75	rr
1906 XI 18				
5. Skager Rak, Kattegat. Denmark				
Da 7				
57°52′,0 N. Lat.	50—0	11°75—9°3	33·51—24·11	cc
11°18′,0 E. Long.				
1906 XI 1				
Da 9				
57°41′,0 N. Lat.	100—0	[11°22]—9°60	[34·02]—22·74	cc
11°23′,0 E. Long.	50—0	7°5—9°60	35·01—22·74	rr
1906 XI 1				
Da 12				
57°24′,8 N. Lat.	30—0	11°80—9°20	33·24—24·88	rr
10°48,0′ E. Long.				
1906 XI 1				
Da 15				
57°17′,9 N. Lat	25—10	[11°6]—9°3	[33·13]—22·01	+
11°27′,4 E. Long.	25—0	[11°6]—8°8	[33·13]—19·89	rr
1906 XI 3	10—0	9°3—8°8	22·01—19·89	÷
Da 18				
56°47′,3 N. Lat.	40—10	11°6—11°4	33·42—32·09	÷
11°47,0′ E. Long.	40—0	11°6—9°0	33·42—20·93	r
1906 XI 3	10—0	11°4—9°0	32·09—20·93	÷

XIV. February 1907

1. North Sea. Belgium

B 2				
51°32′ N. Lat.	32—0	3°73—3°6	33·75—33·62	rr
2°40′ E. Long.	32[1])	3°73	33·75	rr
1907 II 4	0	3°6	33·62	rr
B 10				
50°55′,5 N. Lat.	38—0	3°80—3°26	33·93—33·42	rr
1°31′,7 E. Long.	38[1])	3°80	33·93	÷
1907 II 6	0	3°26	33·42	r
B 11				
50°58′,5 N Lat.	60—0	4°25—4°30	34·79—34·40	÷
1°27′,5 E. Long.	60[1])	4°25	34·79	÷
1907 II 6	0	4°30	34·40	rr

[1]) horizontal.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
2. North Sea. Holland				
H 1				
53°15′ N. Lat.	0	3°6	34·14	rr
4°15′ E. Long.				
1907 II 5				
3. North Sea. Germany				
DN 2				
55°18′,5 N. Lat.	41—0	[4°53]—4°59	[34·69]—34·60	×
4°32′ E. Long.	0	4°59	34·60	÷
1907 II 18				
DN 6				
57°55′ N. Lat.	95—50	[5°65]—5°61	[35·14]—34·87	×
4°45′ E. Long.	50—0	5°61—4°69	34·87—33·98	×
1907 II 24	0	4°69	33·98	×
DN 7				
58°10′ N. Lat.	290—75	6°05—6°49	35·14—34·78	×
5°12′,5 E. Long.	75—10	6°49—4°07	34·78—33·55	×
1907 II 24	10—0	4°07—4°19	33·55—33·46	×
	0	4°19	33·46	×
DN 8				
58°22′ N. Lat.	326—75	[6°05]—6°25	[35·14]—34·60	×
5°31′ E. Long.	75—10	6°25—5°43	34·60—34·16	×
1907 II 24	10—0	5°43—5°24	34·16—34·14	×
	0	5°24	34·14	×
DN 9				
57°52′ N. Lat.	440—340	[5°96]—[6°54]	[35·14]-[35·16]	×
7°20′ E. Long.	340—75	[6°54]—6°30	[35·16]—34·69	×
1907 II 25	75—30	6°30—3°17	34·69—32·48	×
	30—0	3°17—1°17	32·48—28·71	×
	0	1°17	28·71	÷
DN 10				
57°32′ N. Lat.	210—75	[5°74]—6°22	[35·17]—34·92	×
7°36′ E. Long.	75—30	6°22—4°33	34·92—33·42	×
1907 II 25	30—0	4°33—2°39	33·42—31·38	×
	0	2°39	31·38	×
DN 11				
57°17′ N. Lat.	53—0	4°44—4°69	35·10—34·30	×
7°47′ E. Long.	0	4°69	34·30	÷
1907 II 26				
DN 12 a				
56°58′ N. Lat.	30—0	4°23—4°39	34·97—35·01	×
7°44′ E. Long.				
1907 II 26				
DN 14				
56°13′ N. Lat.	28—0	3°68—3°79	34·56—34·56	×
7°21′ E. Long.	0	3°79	34·56	×
1907 II 27				
DN 15				
55°02′ N. Lat.	24—0	2°68—2°24	34·04—32·27	×
7°30′ E. Long.	0	2°24	32·27	÷
1907 II 27				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
4. North Sea. Scotland				
Sc 22				
59°36′ N. Lat.	0	6°15	35·23	r
0°41′ W. Long.				
1907 II 13				
Sc 23				
59°31′ N. Lat.	138—0	5°66—5°55	35·11—35·18	r
0°37′ E. Long.				
1907 II 24				
Sc 24				
58°55′ N. Lat.	138—0	5°79—5°65	35·17—35·20	r
0°04′ E. Long.				
1907 II 24				
5. Skager Rak. Sweden				
S Skag 0				
57°41′ N. Lat.	65—20	[2°21]—2°20	[33·12]—33·12	c
11°23′ E. Long.	20—0	2°20—2°1	33·12—31 60	c
1907 II 21	0	2°1	31·60	rr
S Skag 1				
58°03′ N. Lat.	190—100	[4°74]—5°06	[34·99]—34·97	r
10°48′ E. Long.	60—30	5°34—6°06	34·92—34·87	r
1907 II 23	0	3°30	32·75	÷
S Skag 2				
57°53′ N. Lat.	110—60	[3°70]—4°02	[34·63]—34·58	+
10°42′ E. Long.	50—20	4°12—4°17	34·54—34·27	+
1907 II 21	10—0	3°28—2°8	33 12—32·65	r
	0	2°8	32·65	r
S Skag 3				
58°12′ N. Lat.	225—125	[5°00]—4°95	[34·97]—34·97	+
10°29′ E. Long.	100—40	5°60—5°54	35·01—34·54	+
1907 II 23	20—0	2°58—2°5	32·48—32·16	÷
	0	2°5	32·16	r
S Skag 4				
58°13′ N Lat.	50—0	3°50—2°4	34·25—33·01	r
11°00′ E. Long.	0	2°4	33·01	r
1907 II 27				
S Skag 5	73—0	3°57—3°55	34·72—34·69	cc
57°42′ N. Lat.	0	3°55	34·69	cc
9°51′ E. Long.				
1907 II 23				
S Skag 6				
57°56′ N. Lat.	95—0	[4°08]—3°6	34·74—34·00	c
9°40′ E. Long.	0	3°6	34·00	+
1907 II 24				

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
S Skag 8				
58°26′ N. Lat.	520—0	[5°76]—2°5	[35·16]—32·14	r
9°44′ E. Long.	520—300	[5°76]—6°15	[35·16]—35·23	rr
1907 II 24	100—30	7°21—6°48	35·07—34·67	r
	0	2°5	32·14	r
S Skag 9				
58°21′ N. Lat.	230—50	[4°79]—4°30	[34·76]—34·16	+
8°56′ E. Long.	50—0	4°30—0°7	34·16—28·82	÷
1907 II 24	0	0°7	28·82	÷
S Skag 10				
58°48′ N. Lat.	130—40	[4°80]—5°69	[34·85]—34·70	+
10°23′ E. Long.	20—0	2°81—0°8	32·74—31·55	÷
1907 II 25	0	0°8	31·55	÷
S Skag 13				
58°36′ N. Lat.	225—75	5°20—4°83	34·87—34·40	c
9°20′ E. Long.	50—0	4°05—1°1	34·11—30·12	+
1907 II 24	0	1°1	30·12	÷
S Skag 14				
58°49′,6 N. Lat.	230—125	[6°78]—5°98	[34·96]—34·47	c
11°05′,7 E. Long.	100—40	5°62—5°41	34·34—34·04	c
1907 II 25	40—0	5°41—2°9	34·04—32·00	+
	0	2°9	32·00	÷
S Skag 15				
58°15′,8 N. Lat.	40—0	2°73—2°08	33·82—31·51	+
11°26′,8 E. Long.	0	2°08	31·51	+
1907 II 26				
S Skag 16				
58°19′,3 N. Lat.	120—60	[7°62]—3°33	[34·78]—33·69	+
11°32′,6 E. Long.	55—0	[3°33]—2°25	[33·69]—31·38	+
1907 II 26	0	2°25	31·38	+
S Skag 17				
58°27′,7 N. Lat.	64—5	4°12—2°50	33·77—30·86	+
11°37′,8 E. Long.				
1907 II 26				
6. Skager Rak. Denmark				
Da 9				
57°41′,0 N. Lat.	89—0	3°7—÷0°2	[33·40]-[23·45]	c
11°23′,0 E. Long.	20—0	3°75—÷0°2	33·22—[23·45]	rr
1907 II 1				
7. Baltic. Germany				
DO 1				
54°29′,5 N. Lat.	19—0	1°09—0°39	20·26—18·00	×
10°21′ E. Long.	0	0°39	18·00	÷
1907 II 4				
DO 3				
54°36′ N. Lat.	32—5	1°29—0°15	20·07—13·82	×
11°02′ E. Long.	5—0	0°15—0°00	13·82—13·55	÷
1907 II 5	0	0°00	13·55	÷
DO 5				
54°28′ N. Lat.	26—0	1°19—0°59	16·22—9·02	×
12°15′ E. Long.	0	0°59	9·02	×
1907 II 5				
DO 8				
54°′54 N. Lat.	35—0	1°19—1°44	10·90—8·06	×
13°12′ E. Long.	0	1°44	8·06	÷
1907 II 6				

XV. May 1907

1. North Sea. Belgium

B 1				
51°23′ N. Lat.	18—0	8°4—8°52	31·09—30·50	rr
2°58′ E. Long.				
1907 IV 29				
B 2				
51°32′,3 N. Lat.	64[1])—0	8°[2])—8°	34·23[2])—34·18	rr
2°40′ E. Long.	0	8°	34·18	rr
1907 IV 29				

2. North Sea. Germany

DN 1				
54°41′ N. Lat.	39—0	[6°21]—6°72	[34·58]—34·58	×
6°12′ E. Long.	0	6°72	34·58	÷
1907 V 5				
DN 7				
58°10′ N. Lat.	280—100	5°67—6°16	35·07—34·88	×
5°12′,5 E. Long.	100—0	6°16—6°64	34·88—33·57	÷
1907 V 10				
DN 8				
58°22′ N. Lat.	300—100	5°61—5°47	35·07—34·88	×
5°31′ E. Long.	100—0	5°47—6°57	34·88—32·86	÷
1907 V 10				
DN 9				
57°52′ N. Lat.	430—150	[5°61]—5°3	[35·07]—34·70	×
7°20′ E. Long.	150—0	5°3—8°70	34·70—26·36	÷
1907 V 11				
DN 10				
57°32′ N. Lat.	220—100	[5°70]—5°78	[35·07]—34·97	×
7°36′ E. Long.	100—0	5°78—7°14	34·97—33·67	÷
1907 V 11				
DN 14				
56°13′ N. Lat.	30—0	5°91—8°61	33·91—33·82	×
7°21′ E. Long.	0	8°61	33·82	÷
1907 V 12				
DN 15				
55°02′ N. Lat.	24—0	6°44—8°85	32·97—32·63	×
7°30′ E. Long.	0	8°85	32·63	÷
1907 V 13				

[1]) hardly correct. [2]) Measurements taken at 36 m.

Station	Depths in Meters	Temperature in C°	Salinity ‰	Frequency
3. Skager Rak. Sweden				
S Skag 1				
58°03′ N. Lat.	160—20	[5°52]—5°49	[34·94]—33·66	r
10°48′ E. Long.	10—0	6°29—6°6	30·90—29·88	÷
1907 V 5				
S Skag 3				
58°12′ N. Lat.	300—100	[5°61]—5°38	[35·01]—34·83	r
10°29′ E. Long.	100—0	5°38—5°94	34·83—27·83	÷
1907 V 3				
S Skag 4				
58°13′ N. Lat.	120—15	[5°03]—[5°59]	[34·74]-[33·66]	r
11°00′ E. Long.	10—0	6°30—6°32	28·21—27·61	÷
1907 V 3				
S Skag 5				
57°42′ N. Lat.	60—10	5°70—6°02	33·91—33·22	÷
9°51′ E. Long.	5—0	[6°02]—6°07	[33·22]—33·15	rr
1907 V 5				
S Skag 6				
57°56′ N. Lat.	58—15	[5°58]—[5°69]	[34·14]-[33·77]	r
9°40′ E. Long.	10—0	5°76—6°3	33·68—31·22	÷
1907 V 5				
S Skag 7				
58°26′ N. Lat.	537—200	[5°66]—5°56	[34·99]—34·92	+
9°44′ E. Long.	200—20	5°56—3°93	34·92—32·90	rr
1907 V 4	10—0	5°95—6°20	26·42—24·87	÷
S Skag 8				
58°10′ N. Lat.	537—200	[5°67]—5°70	[35·01]—35·01	r
9°18′ E. Long.	200—30	5°70—6°03	35·01—34·18	rr
1907 V 5	20—0	4°67—6°2	33·04—25·19	÷
S Skag 9				
58°21′ N. Lat.	300—20	[5°22]—3°88	[34·88]—32·12	r
8°56′ E. Long.	15—0	3°92—5°9	30·77—26·09	÷
1907 V 5				
S Skag 10				
58°48′ N. Lat.	160—20	[5°41]—4°25	[34·96]—33·75	r
10°23′ E. Long.	10—0	4°78—6°0	33·01—27·81	÷
1907 V 4				
S Skag 13				
58°36′ N. Lat.	280—100	[5°43]—5°24	[34·63]—34·74	r
9°20′ E. Long.	100—0	5°24—5°90	34·74—26·13	÷
1907 V 4				
S Skag 16				
58°19′,3 N. Lat.	110—60	[4°41]—4°71	[34·49]—34·60	r
11°32′,6 E Long.	50—0	4°52—6°22	34·38—29·65	÷
1907 V 2				
4. Skager Rak, Kattegat. Denmark				
Da 4				
57°57′,7 N. Lat.	190—0	5°5—6°3	34·99—25·95	rr
10°49′,6 E. Long.				
Da 15				
57°17′,9 N. Lat.	75—0	5°0—6°5	34·90—23·50	rr
11°27′,4 E. Long.				

VIII. Literature.

1905. Apstein, C.: Plankton in Nord- und Ostsee auf den deutschen Terminfahrten. 1. Teil (Volumina 1903). — Wiss. Meeresunters. Komm. z. Unters. d. d. Meere, Abt. Kiel, Neue Folge, Bd. 9.

1908. — —: Übersicht über das Plankton 1902—07 in: Die Beteiligung Deutschlands an der internat. Meeresforschung, IV—V. Jahresbericht, Berlin, pp. 41—54.

1906. Bidder, Geo. P.: Résultats principaux des expériments avec flotteurs de fond (Principal results of the experiments with Bottom-Trailers). — Conseil permanent internat. p. l'explor. de la mer, Rapports et Procès-verbaux, Copenhague, vol. VI, pp. XXXV—XLII.

1905. Börgesen, F.: The Algæ-vegetation of the Færöese Coasts. — Botany of the Færöes, vol. III, Copenhagen. (Sep. 1905.)

1900. Boyer, Charles S.: The Biddulphoid Forms of North American Diatomaceæ. — Proc. Acad. Nat. Sc. Philadelphia, pp. 685—748.

1903. Breemen, P. J. van: Über das Vorkommen von Oithona nana Giesbr. in der Nordsee. — Conseil permanent internat. pour l'explor. de la mer. Publ. de Circonstance, Copenhague, No. 7.

1906. — —: Bemerkungen über einige Planktonformen. — Verhandl. Rijksinstituut Onderzoek der Zee, Helder, I, 5.

1906. Brockmann, Chr.: Ueber das Verhalten der Planktondiatomeen der Meeres bei Herabsetzung der Konzentration des Meereswassers und über das Vorkommen von Nordseediatomeen im Brackwasser der Wesermündung. — Wiss. Meeresunters. Komm. z. Unters. d. d. Meere, Abt. Helgoland, N. F., Bd. 8.

1908. — —: Das Plankton im Brackwasser der Wesermündung. — Aus der Heimat — für die Heimat, Beitr. z. Naturkunde Nordwestdeutschlands, N. F., Heft 1, Leipzig, pp. 32—57.

1904—05. Bulletin des résultats acquis pendant les courses périodiques publié par le bureau du conseil permanent international pour l'exploration de la mer. Nov. 1903—Mai 1905. Copenhague.

1906—08. Bulletin trimestriel des résultats acquis pendant les croisières périodiques et dans les périodes intermediaires, publié par le bureau etc. Juillet-Sept. 1905—Avril-Juin 1907. Copenhague.

1873. Cleve, P. T.: Examination of Diatoms found on the Surface of the Sea of Java. — Bih. Svenska Vetensk. Akad. Handl., Bd. I, N. 11, p. 6.

1900. — —: The Seasonal Distribution of Atlantic Plankton Organisms. Göteborg, p. 288 and p. 24.

1905. — —: Report on the Plankton of the Baltic Current, collected from August 1903 to July 1904 at the Swedish Coast-stations Måseskär and Väderöbod. — Svenska hydrografisk-biologiska komm. skrifter, II, Göteborg.

1908. Cotton, A. D.: The Appearance of Colpomenia sinuosa in Britain. — Roy. Bot. Gardens, Kew Bull., No. 2, pp. 73—77.

1907. Driver, H.: Das Ostseeplankton der 4 deutschen Terminfahrten im Jahre 1905. — Wiss. Meeresunters. herausgegeb. v. d. Komm. z. Unters. d. d. Meere. Abt. Kiel. Neue Folge. Bd. 10.

1906. Fabre-Domergue: Une invasion d'Algues méridionales sur les huîtres de la rivière de Vannes. — Compt. Rendus, Acad. Sc. Paris, No. 22.

1896. Fulton, T. W.: On the currents of the North Sea and their relations to fisheries. — Annual Rep. Fishery Board for Scotland, vol. XV.

1901. Gilson, G.: Exploration de la Mer du Nord sur les côtes de la Belgique en 1899. — Mém. du Musée Roy. d'Hist. naturelle de Belgique, tome I, Année 1900.

1905. Gran, H. H.: Diatomeen, in: Apstein und Brandt, Nordisches Plankton. XIX.

1866. Greville, K. K. L. D.: Descriptions of new and rare Diatoms, ser. XIX. — Transact. Microsc. Soc., London, p. 81, Pl. 9, fig. 16.

1907. Helland-Hansen, B.: Current-Measurements in Norwegian Fiords, the Norwegian Sea and the North Sea in 1906. — Bergens Museums Aarbog 1907, No. 15.

1899. Knudsen, Martin: De hydrografiske Forhold i de danske Farvande indenfor Skagen i 1894—98. — Beretn. Komm. f. vidensk. Unders. af de danske Farvande, Bd. 2, Hefte 2, Kjøbenhavn.

1907. — —: Some Remarks about the Currents in the North Sea and adjacent Waters. — Conseil permanent internat, p. l'explor. de la mer. Publ. de Circonstance, Copenhague, No. 39.

1907. Kraefft, F.: Plankton in "Eine Fahrt des "Poseidon" in das Fanggebiet der Grossen Heringsfischerei". — Mitteil. d. D. Seefischerei-Vereins. No. 8—9, 1907.

1904. Krümmel, Otto: Die Deutschen Meere im Rahmen der internationalen Meeresforschung. — Veröff. Institut f. Meereskunde. Berlin, Heft 6.

1904. Nautical-Meteorological Annual 1903, published by the Danish Meteorological Institute. Kjøbenhavn.

1879. O'Meara, E.: Biddulphia chinensis from Yeddo Sea. — Quartl. Journ. Microsc. Science, New ser., vol. 19, p. 120.

1902. Ostenfeld, C. H.: Marine Plankton Diatoms, Flora of Koh Chang, Part VII. — Botanisk Tidsskrift, vol. 25. København, p. 25, fig. 21.
1908. — —: Planktonundersøgelserne, in „De internationale Havundersøgelser 1902—1907". — Skrifter udg. af Komm. for Havundersøgelser, No. 4, pp. 23—26. København.
1901. — — and Schmidt, Johs.: Plankton from the Red Sea and the Gulf of Aden. — Vidensk. Medd. Naturh. Forening, København, p. 152. fig. 6.
1908. Pettersson, O.: Strömstudier vid Östersjöns portar. (Swedish with German Résumé.) — Svenska hydrografisk-biologiska komm. skrifter, III, Göteborg.
1906. Sauvageau, C.: A propos du Colpomenia sinuosa signalé dans les huîtrières de la rivière de Vannes. — Bull. Stat. biolog. d'Arcachon, 9. année, 14 pp.
1888. Schmidt, A.: Atlas der Diatomaceenknnde. Taf. 122, figs. 22—24.
1906. Schröder, Bruno: Beiträge zur Kenntnis des Phytoplanktons warmer Meere. — Vierteljahrsschrift d. Naturf. Ges., Zürich, Jahrg. 51.
1859. Schultze, Max: Phenomena of internal movements in Diatomaceæ of the North Sea, belonging to the Genera Coscinodiscus, Denticella and Rhizosolenia. — Quart. Journ. Microsc. Sc., London, VII, pp. 13—21, Pl. 2.

Notes to the Charts.

On the Charts are indicated all the known occurrences of *Bidd. sinensis* within the North Sea and adjacent seas, also most of the plankton stations where the species was lacking within a region extending from 63° N. L. to 50° N. L. and from 2° W. to 20° E. An explanation of the signs used is given on Chart I.

The following notes to the different charts may be given here: the position of most of the German stations in the North Sea in February 1904 and of those of Norway in the Norwegian Sea in May 1905 is approximate. On the August Chart for 1905 the data from Heligoland are for July, those for the mouth of the Weser from the end of August to November and for the station at 55° 7′ N. L., 1° 43′ E. L. from September 15th.

On the February Chart for 1906, the Swedish Skager Rak stations are for March; on the May Chart for 1906, the Scottish stations are for April.

Postscript.

After the text of the present paper was printed I received a paper by J. P. Jacobsen and A. C. Johansen entitled: Remarks on the changes in specific gravity of pelagic fish eggs and the transportation of same in Danish waters (Medd. Komm. Havundersøgelser, Fiskeri, Bd. III, Nr. 2, København 1908). The authors give here some interesting notes on the rate of flow of the currents in the Kattegat, which ought to be compared with my statements.

550. 24/xi 1908.

Chr. J. Cato lit.

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